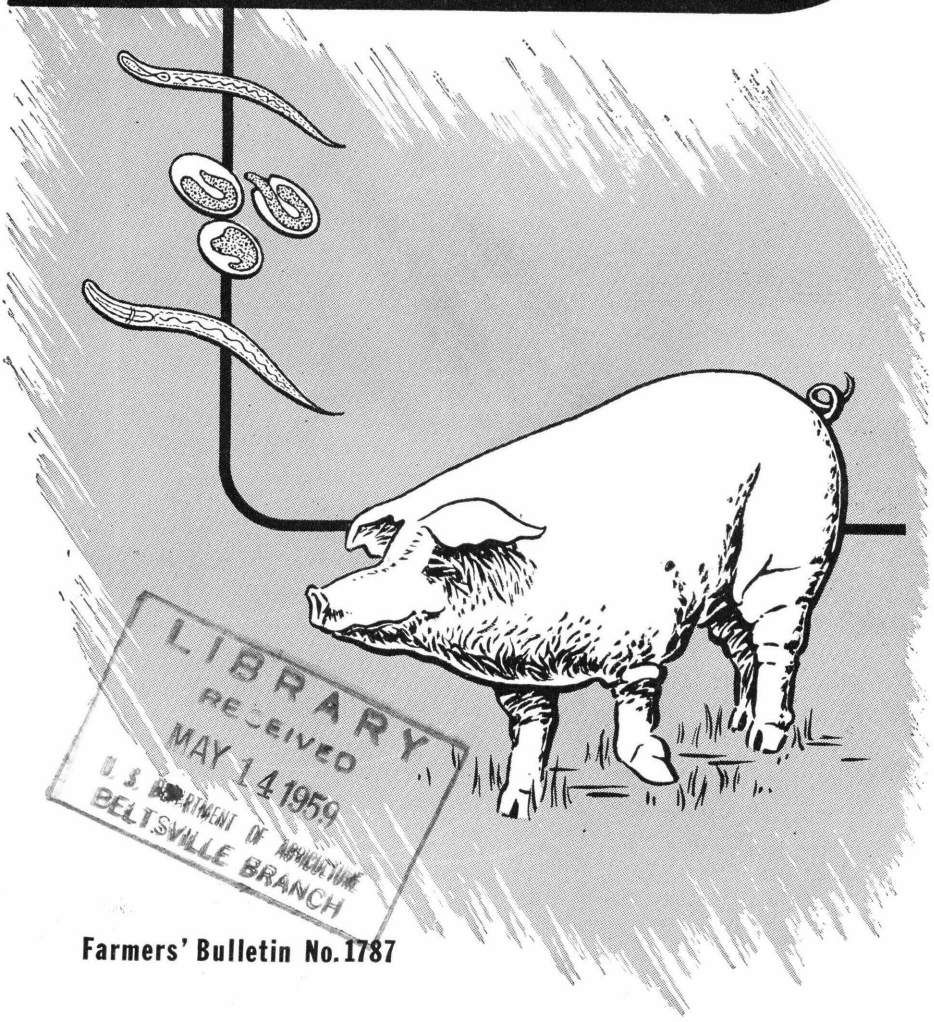
INTERNAL PARASITES OF SWINE



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U. S. DEPARTMENT OF AGRICULTURE

THE HOG is generally considered to be a dirty animal. Experience shows, however, that given a chance to graze in a clean pasture and sleep in a dry, clean place, it will do so, thus growing faster and making a better profit for its owner.

This bulletin is written in answer to inquiries, largely from swine owners who find evidence of infestation with parasites in hogs they slaughter on their farms. It is designed to tell them how to identify most of the common parasites and how to prevent such infestations.

In some parts of the United States hogs are so seriously infested with internal parasites that meat packers make deductions from the prevailing market prices to offset losses due to the necessary elimination of damaged parts.

Swine owners who take special precautions to prevent infestation of their young pigs should reap greater profits from their animals by being able to raise to market age more pigs from each litter. There is also a saving in feed; healthy animals mature and fatten on less than is needed by parasitized pigs.

You may contact your county agricultural agent, State agricultural experiment station, or you may write to the U. S. Department of Agriculture for information on external parasites and bacterial diseases that affect swine.

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INTERNAL PARASITES OF SWINE

By the Animal Disease and Parasite Research Division, Agricultural Research Service

CONTENTS

THE INTERNAL PARASITES that infest swine vary widely in structure, size, shape, habits, and degree of injuriousness. Some are very simple in construction and so minute that they can be seen only with a high-powered microscope. Known as Protozoa, they belong to the lowest group in the animal kingdom. The other parasites discussed here are worms having a more complex structure. When full-grown they are visible to the naked eye, although several of them are so small that ordinarily they would be detected only by a specialist. The worm parasites fall into three groups—flukes, tapeworms, and roundworms—each with a characteristic shape. Roundworms are the most important parasites of swine in the United States.

Some swine parasites live in various parts of the digestive tract; some in the lungs, liver, kidneys, muscles, and other places outside the digestive tract. Wandering young worms penetrate different parts of the body in their migrations. Practically all tissues and cavities of hogs may harbor parasites at one time or another.

GENERAL EFFECTS OF INTERNAL PARASITES

Swine are seriously affected by internal parasites of various kinds. Even comparatively light infestations with large intestinal roundworms, intestinal threadworms, "thornyheads" or thorn-headed worms, nodular worms, whipworms, kidney worms, and lungworms may reduce pigs to a state in which they are neither well nor definitely sick; in other words, the pigs become unthrifty. Heavy infestations produce emaciation, diarrhea, or constipation and may end fatally. The conditions under which pigs are commonly kept in many parts of the United States are highly favorable to the spread of parasitism and its associated evils of unthriftiness, stunting, weakness, emaciation, and high mortality among young pigs. Much, if not most, of the mortality among young pigs is due to parasitic infestations acquired early in life, perhaps during the first few days.

Parasites not only devitalize pigs by robbing them of essential feed and injuring many vital organs, but, in addition, probably make them more susceptible to infection with bacteria and other disease-producing agents. The migration of developing worms through organs and tissues results in disability. In mass migrations of worms through the liver, lungs, and blood vessels, and in the abdominal and chest cavities, serious consequences are likely, particularly in young pigs.

Young pigs are not only more susceptible to infestation with internal parasites, but they also suffer more severely than older pigs from them. Pigs and other young animals require special care to protect them from an onslaught by parasites and other disease-producing organisms at a period in life when their susceptibility to disease is at its height and when they lack the hardiness to cope with disease-producing invaders. Due attention to the protection of pigs early in life, particularly during the first few weeks after they have been farrowed, will save losses from lack of condition, stunting, and death. It will more than repay the cost of protection against parasites.

The oft-repeated warning that an ounce of prevention is worth a pound of cure finds no better illustration than in swine-husbandry operations. Hog growers who are careless with their newly farrowed pigs, and make no special provisions for taking care of them, frequently spend relatively large sums later for drugs, tonics, and conditioners, many of which are practically worthless for alleviating a weakened condition brought about by infestation with internal parasites, or for removing parasites. A little well-directed energy spent in protecting pigs from the ravages of parasites is not only cheaper but also far more effective than much of the medication to which many hog producers resort.

Besides preventing losses among pigs, control measures against parasites, if carefully and persistently followed, bring about a permanent improvement in swine husbandry by curtailing the sources of infection—the infested hogs which discharge parasite eggs and the infested pastures and lots on which the eggs and larvae survive.

CONTROL MEASURES

Prevention, in the broad sense, covers all efforts directed toward avoiding infestation or minimizing its effects. The cardinal principle of prevention is sanitation, or cleanliness. Seventy years ago an eminent parasitologist stated that the way to control parasites in swine is to raise the animals under less swinelike conditions. This advice is as sound today as when it was offered. The association of the word "swine" with the word "filth" is the result, no doubt, of the filthy conditions under which swine are kept in some places. Old hog lots with their accumulation of manure and litter, combined with hog wallows, are anything but a pleasing sight (fig. 1). To expect animals raised in insanitary surroundings to develop normally and to produce healthy offspring is unreasonable. For normal growth and development, swine require sanitary surroundings, a balanced and adequate ration, and relative freedom from parasites (fig. 2).

Sanitary surroundings include clean housing, the houses to be of sanitary construction so that the floors and walls can be swept and scrubbed to remove manure, litter, and dirt. The outdoor surroundings should be pastures sown to suitable forage crops. The pastures

1384-ZOOL.

FIGURE 1.—Three pigs of the same age in a hog lot littered with corncobs and otherwise in a condition favorable to the development of parasites. The two smaller pigs already show the effects of hog-lot infections.

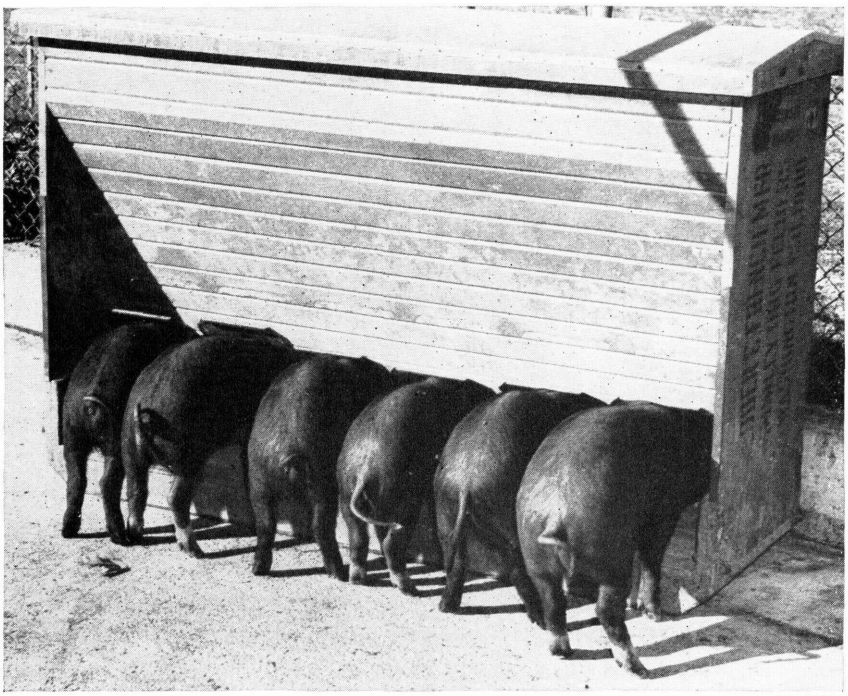

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FIGURE 2.—A self-feeder on concrete in a clean hog lot. These young pigs are free from parasites and thus able to develop normally.

should be well drained and provided with good fences to keep pigs from getting into low and wet areas. The pastures should be free from litter; eggs and larvae of parasites thrive under accumulations of all sorts.

Permanent pastures are far less desirable than temporary pastures. If permanent pastures must be used, however, it is essential to rotate stock so as not to keep pigs year after year on the same land. Temporary pastures, if well kept, well drained, and sown to suitable forage crops, offer the best and simplest way to control swine parasites. Experience in several parts of the country, notably the Middle West and the South, has shown that raising pigs on temporary pastures causes practically all stunting, diarrhea, general unthriftiness, and such associated conditions as bullnose and mange to disappear. Pigs produced under these conditions are more uniform in size, grow faster, and are almost always more profitable than pigs produced under less favorable conditions. Such well-kept pigs develop at a reasonably rapid rate, are remarkably uniform in size, and under normal market conditions yield a good profit on the investment in breeding stock, feed, and labor. Pigs raised under sanitary conditions require less feed and are ready for market several weeks earlier than pigs raised without special precautions; losses, therefore, are lower.

In brief, the problem to be solved in parasite control is the protection of pigs from the parasites harbored by sows and older pigs generally. Assuming that it is impracticable to dispose of infested breeding stock and also that it would be difficult to acquire parasite-free breeding stock, even if the stock on hand could be disposed of, the hog raiser faces the problem of avoiding excessive infestation in his growing pigs. The first essential is to eliminate as far as possible the sources of infection. This entails the judicious use of specific medication for breeding stock and all other swine on the premises. Ideally, pigs should be placed on a pasture not contaminated with eggs and larvae of swine parasites or on one that has had a crop on it since it was last occupied by hogs. As an alternative, a permanent pasture that has not had pigs on it for about a year may be used. A second important precaution is to keep all hogs, other than the sows, away from the suckling litters and young pigs, thus preventing contamination of the pastures with eggs and larvae, especially those of parasites for which no effective treatments are known. Finally, the pasture on which pigs are kept must be well drained and the feeding grounds must be kept free of trash, so that the parasite eggs and larvae which issue from the eggs passed with feces or urine of the sow will be exposed to the action of the sun, air, and other natural factors that are injurious to eggs and larvae of parasites. Such precautions will not prevent parasitic infestation of suckling pigs altogether; but they will keep the infestations down to a low level. If the pigs are properly fed and housed, protected from association with older hogs other than their mothers, and kept on clean pastures before and after weaning, the light infestations that they will inevitably acquire from the sows will do comparatively little harm.

TREATMENT FOR REMOVAL OF PARASITES

Treatment of infested swine for the removal of parasites is an essential part of good management. By removal of adult parasites, the

dissemination of these disease agents through eggs and larvae is checked. In addition, the animal from which parasites are removed is afforded relief from the drain of the infestation.

Treatment for the removal of parasites may involve the administration of drugs which are rather toxic. The aim of medication for the removal of parasites is to kill or otherwise affect the parasites so that they will be expelled from the body. Drugs and chemicals that are injurious to parasites may be temporarily injurious also to the host animals. In medication for the removal of parasites the dosage must be adjusted to inflict the least injury on the host animal and the greatest injury on the parasites. Decisions involving the kind of drug to use, precise dosage, method of administration, when treatment should be given for best results, when treatment should be avoided because of the physical condition of the animal, and similar matters require professional knowledge and skill not possessed by most stockmen. Treatment of animals for ailments, including those produced by parasites, is primarily the concern of the veterinarian who is qualified to make a diagnosis to determine whether treatment is practicable, and, if so, to prescribe and administer it. Attempts at medication by stockmen may lead to disaster. There are no established treatments for many of the parasites that infest swine.

The trend in recent years has been toward the development of agents that may be used in group treatment procedures which obviate the need for individual dosing. This method of handling parasite control problems in swine was given considerable impetus by the discovery of phenothiazine and, particularly, by the development of the sodium fluoride treatment. Cadmium, piperazine, and hygromycin are examples of more recent findings of this kind.

Although the large roundworm, or ascarid, is the commonest and most injurious worm parasite of swine, these animals usually harbor a variety of other species that contribute to the overall economic loss attributable to parasitism. The need for agents having a broad spectrum of antiparasitic activity, therefore, is plainly evident; and in this connection, the action of some of the newer chemicals against two or more kinds of worm parasites shows that progress is being made in this important area of parasite control.

The mere fact that worms are passed following treatment is not evidence that the drug used was effective. A very important consideration is the number of worms that failed to be removed by the drug. For instance, the removal of a dozen worms from an animal which harbors a hundred or more does not warrant the expense of treatment. For this reason the treatments recommended in this bulletin are limited to those that have been tested scientifically and found effective in removing all or a large proportion of the worms present in an animal.

Treatment is not a substitute for sanitation. Pigs that have been treated should be moved to clean quarters; otherwise the good that has been accomplished by treatment will be nullified by reinfestation. So long as the treated animals are allowed to remain in the lots or pastures where the infestation was acquired they are subject to reinfestation.

PROTOZOA

Protozoa are the simplest forms of animal life, the individual consisting of an exceedingly minute speck of living matter. Some forms are free living, others are parasitic. The parasitic forms can be seen only with the aid of a microscope.

In spite of their small size they can inflict serious damage. They are responsible for some of the severest diseases that afflict human beings, for example, malaria, amoebic dysentery, and Africa sleeping sickness. Protozoa of livestock and poultry cause important diseases such as tick fever and genital trichomoniasis of cattle, dourine and related diseases of horses, coccidiosis of poultry and livestock, and blackhead of poultry.

DYSENTERY-PRODUCING PROTOZOA

Swine harbor in their intestines a number of Protozoa including forms that are closely related to, if not identical with, those found in human beings. Some, known as amoeba, are practically indistinguishable from those known to produce amoebic dysentery in man. Others, known as balantidia, are apparently identical with forms that produce dysentery in human beings.

The dysentery-producing Protozoa are conveyed from animal to animal by minute rounded bodies known as cysts which are the resistent stage in the life of cycle of the parasite. The cysts are discharged with the droppings. Pigs swallow them while eating or drinking.

It has not been determined to what extent amoeba injure swine. There is evidence that balantidia can be injurious, especially in the case of swine fed principally on corn or garbage. The possibility that these organisms can be transmitted to human beings should be kept in mind. If for no other reason, measures designed to control these parasites in swine are indicated as a human-health safeguard. Measures for the control of coccidiosis may be used.

COCCIDIA

Coccidia attack the lining of the intestines. The damage they do causes scouring and other ill effects which are known as coccidiosis. About six types of coccidia occur in swine in the United States. The

infective stages are known as oöcysts. The largest ones are about one five-hundredth of an inch in diameter. They are discharged with the droppings. Before the oösysts can infect pigs, they must develop in the open.

Life history.—Pigs swallow the oöcysts with feed and water that have become contaminated with the droppings of infected swine. On reaching the intestine, the contents of the oöcyst, consisting of several infective bodies, are liberated. Each infective body is capable of penetrating and damaging a cell of the intestinal lining. It develops at the expense of the cell and produces a number of new infective bodies. Each of the newly formed infective bodies is capable of entering a neighboring cell and repeating the process of development, multiplication, and cell destruction. The multiplication of coccidia does not continue indefinitely, however; if but few oöcysts are swallowed by a pig the few cells that are destroyed by the developing coccidia may not produce serious injury. Sooner or later in the development of coccidia oöcysts are formed. Discharged with the droppings, they propagate the infection. Swine which recover from coccidiosis may continue to discharge oöcysts for a long time. Such pigs are classed as carriers; they transmit coccidiosis to susceptible pigs.

Damage.—In light cases no symptoms are observed. In marked infections pigs may scour, become unthrifty, and emaciated. In extreme cases, which may result in death, loss of flesh is pronounced. These symptoms are associated with a marked destruction of intestinal cells and a swelling and congestion of the intestinal wall.

Treatment.—No effective treatment is known.

Control.—The control of coccidiosis is largely a matter of sanitation. Severe cases usually occur under crowded unsanitary conditions, particularly in pigs raised on old hog lots and on permanent low and wet pastures, which are ideal for the survival of the oöcysts. Infected pigs that were removed from unsanitary surroundings to clean pastures or isolated in houses with concrete floors have shown marked improvement. Removal of an infected pig from the area where the infection was acquired reduces the chances of reinfection and affords opportunity for recovery. The recommendations for controlling the large intestinal roundworm (p. 22) apply also to the control of coccidiosis.

TRICHOMONADS

Another type of Protozoa, known as trichomonads, occurs in the intestine, stomach, and sometimes in the nose of swine. These parasites are pear-shaped and extremely tiny. They move by means of whiplike structures attached to one end of the body. It is not known how trichomonads are conveyed from one pig to another. However,

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pigs kept under unsanitary conditions generally harbor greater numbers of these parasites than do clean pigs. Under ordinary conditions trichomonads in the stomach and intestine are not known to be serious. In severe infections they may cause scouring. Trichomonads in the nose are often associated with atrophic rhinitis. These parasites have not been shown to be sole cause of this disease, however. Trichomonads from the nose and intestinal tract of swine can live in the reproductive tract of cattle. In cows they can cause abortions and other breeding difficulties.

Treatment.—No effective treatment is known.

Control.—Measures for the control of coccidia are applicable to the control of trichomonads. In addition, cattle and swine should not be kept together if infection of cattle with trichomonads of swine is to be avoided.

FLUKES

Flukes are soft, flattened, leaflike worms that exist in various parts of the animals which they parasitize. These worms have rather complicated life histories; they are transmitted from one host animal to another by way of a snail carrier and sometimes by way of an additional intermediate host or carrier. Although a number of different flukes have been recorded from swine in various parts of the world, only two kinds are particularly important in this country.

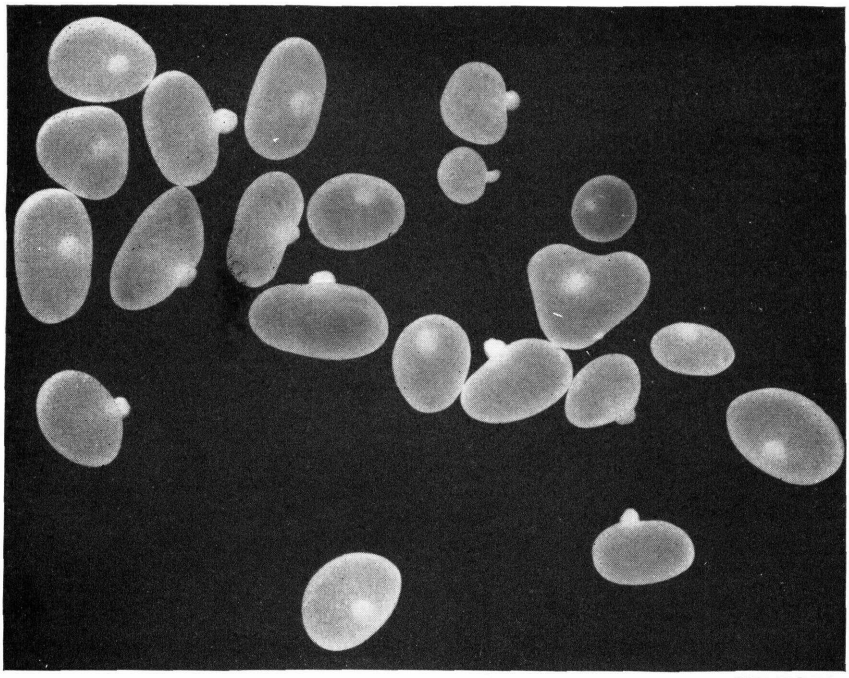
THE COMMON LIVER FLUKE

The common liver fluke, *Fasciola hepatica*, is primarily a parasite of sheep and cattle, but also of other animals, including swine. The worms are about 1 inch long by about one-half inch wide and live in the bile duct and bile canals of the liver. Liver flukes in swine are found only where the animals are kept on low, swampy ground. Such wet areas are likely to harbor aquatic snails, in which the early development of flukes must take place. Sooner or later the young flukes leave the snails. Swine pick up the infestation when they swallow green forage or water harboring the fluke in its infective stage.

Liver-fluke infestation in swine is not a serious problem in this country, so far as is known. As a precaution against infestation with it, swine should be kept off swampy or boggy pastures, especially in the Pacific Coast and Rocky Mountain States and in the South, particularly along the Gulf coast. Liver-fluke infestation is a serious problem in cattle and sheep in those areas.

THE LUNG FLUKE

Lung flukes, *Paragonimus westermanii*, are thick, oval worms, about one-fifth to three-fifths of an inch long and one-fifth of an inch or



867-ZOOL.

FIGURE 3.—Pork bladder worms removed from muscles. (Natural size.)

less wide. They exist in sacs or cysts in the substance of the lungs.

Life history.—The eggs produced by the flukes in the lungs are coughed up and swallowed and then discharged with the droppings. In swampy areas the eggs hatch, and the young flukes get into certain aquatic snails, in which they develop. They leave the snails and develop further in crayfish. Hogs rooting in wet and boggy pastures have ample opportunity for bringing crayfish to the surface and devouring them. Once free in the digestive tract of a hog, the young flukes bore their way through the intestinal walls, wander to the lungs, which they penetrate, and there develop to egg-laying maturity.

Damage.—No special symptons have been noted in affected hogs, largely because the infestation has not been studied extensively in these animals. The presence of flukes in the lungs produces an inflammation. When an infested lung is viewed superficially the cysts generally appear as dark areas; if the cysts are deep in the lungs, the surface of this organ may show only a swelling.

Treatment.—There is no known treatment that removes lung flukes from swine.

Control.—Control of lung-fluke infestation in swine is based on the mode of transmission. Keep hogs off wet and boggy areas. If necessary, fence such areas to prevent access to them.

TAPEWORMS

Tapeworms infest domestic animals either as adults in the intestine or as bladder worms outside the digestive tract. On casual examination there is little resemblance between a bladder worm and an

adult tapeworm. Actually, however, a bladder worm is an incompletely developed tapeworm consisting of a fully formed head and neck. The head of the bladder worm discussed here bears four cup-shaped suckers and a double crown of hooks for the attachment of the future tapeworm to the wall of the final host's intestine. The head and neck are inverted into the thin-walled bladder at one end, the arrangement resembling the tip of a glove finger that is pushed in at the end. The inverted head and neck appear as an opaque object in the bladder, which is filled with a clear fluid.

If a bladder worm or part of a carcass containing one or more bladder worms is eaten by an animal capable of harboring the adult tapeworm, the head and neck of the bladder worm are turned outward in the stomach, and the wall of the bladder portion of the worm is digested on reaching the intestine, the head becomes attached to the wall by means of its suckers and hooks, and the neck begins to bud off segments, forming in the course of about 2 months a jointed, flattened, whitish worm which may attain a length of several feet.

Domestic hogs in the United States are not known to harbor adult tapeworms in the intestines. They do harbor three species of bladder worms, however, one of which develops into an intestinal tapeworm in man and the other two into tapeworms in the intestines of dogs.

THE PORK BLADDER WORM

The tapeworm, *Taenia solium*, infests hogs in the immature, or bladder-worm, stage. The full-grown, or adult, tapeworm, known as the pork tapeworm, infests human beings. The bladder-worm stage is spherical to lemon-shaped and from one-fifth to two-fifths of an inch in maximum diameter (fig. 3).

The pork bladder worm lodges in the muscles of hogs, especially the muscles of the abdomen, the muscular portion of the diaphragm, the loin muscles, the heart (fig. 4), the muscles used in chewing, the

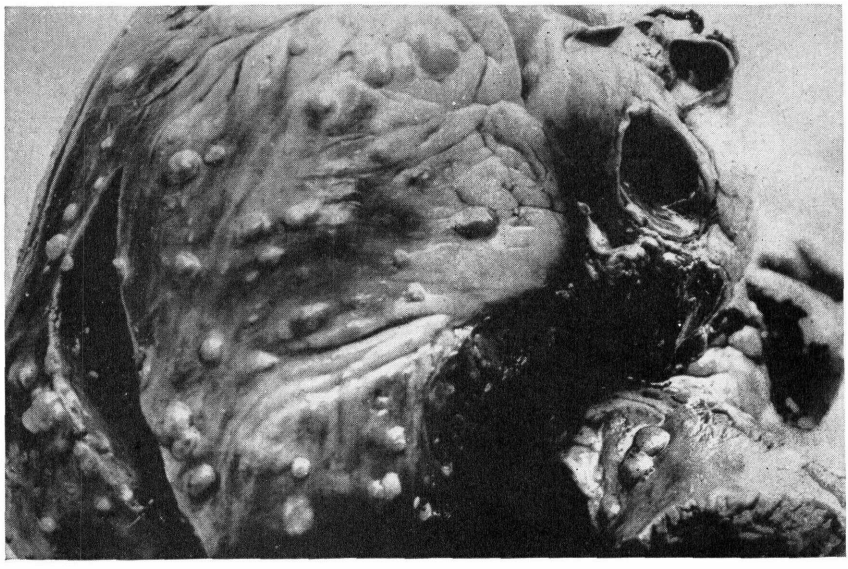


FIGURE 4.—Hog heart heavily infested with the pork bladder worm.

tongue, the muscles between the ribs, certain muscles of the hind legs, and shoulder muscles. It has been found also in the brain, eyes, liver, lungs, pancreas, and spleen.

Life history.—When a human being swallows a live pork bladder worm with raw or incompletely cooked pork the combined action of the digestive fluid and the warmth of the stomach causes the head and the neck of the worm to be pushed out, leaving the shrunken bladder behind the neck; the wall of the bladder is digested. On reaching the small intestine, the parasite attaches itself to the intestinal wall by means of its suckers and hooks and develops, in the course of about two months, into a gravid (egg-producing) tapeworm (fig. 5). The tapeworm may attain a length of 3 to 6 feet, the longest joints in the tail end being about half an inch long and one-third of an inch wide. The joints or segments at the tail end become detached from the tapeworm chain and are expelled with the excreta, new segments taking their place by growth in the region of the neck.

The detached segments expelled with the excreta contain numerous eggs which are liberated as the segments disintegrate. Pigs become infested as a result of swallowing the tapeworm eggs or entire segments, each containing hundreds of eggs. On getting into the pig's digestive canal, the eggs hatch and the young worms, which escape from the eggshells, bore into the wall of the digestive canal and are carried by the blood stream, aided probably by their own migrations, to various parts of the animal's body.

Damage.—No definite symptoms are associated with bladder-worm infestation of swine. Infestation is diagnosed, as a rule, after death upon the discovery of the worms in the muscles and other places. Pork infested with bladder worms is commonly known as measly pork. Because of the danger to human health from eating raw or imperfectly cooked measly pork, special precautions are taken to detect these parasites in swine carcasses under Federal, State, and local meat inspection. Lightly infested carcasses are passed for human food only after sterilization, following the removal of visible cysts; if the infestation is excessive the carcass is condemned and not used for food.

Treatment.—There is no known practical treatment for the removal of bladder worms from swine.

Prevention.—Infestation can be prevented by a sound system of rural sanitation. Pigs become infested only as a result of swallowing tape-

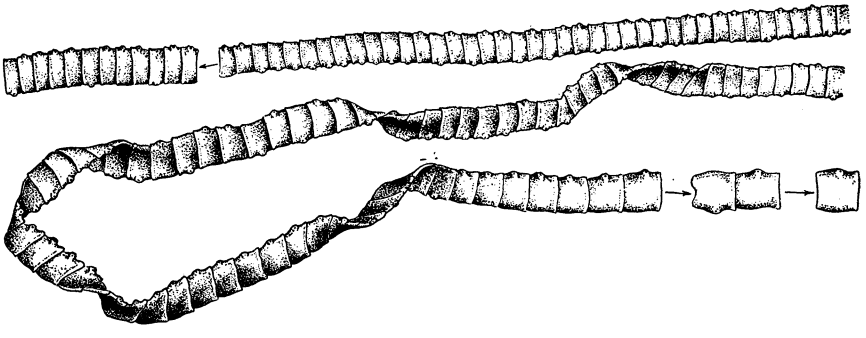


FIGURE 5.—Portions of a pork tapeworm from the human intestine. (Nearly one-half natural size.)

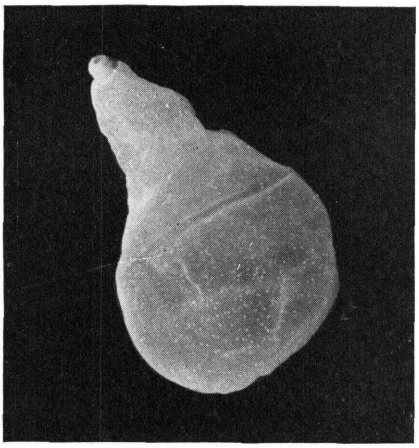


FIGURE 6.—The thin-necked bladder worm. (Natural size.)

2382-ZOOL.

FIGURE 7.—Thick stomach worms on the inner surface of a hog's stomach. (Natural size.)

worm segments or eggs with feed and water that have become contaminated with human excreta or by rooting in contaminated soil. Proper disposal of human excreta will prevent contamination of areas to which swine have access. As the tapeworm cysts become rarer in swine the adult tapeworm also becomes rarer in man; thus the vicious cycle of the parasite is gradually destroyed.

The pork bladder worm is becoming rather rare in hogs in this country. It is found in swine only where the level of human sanitation is still far below accepted standards. The pork tapeworm is also capable of developing to the bladder-worm stage in human beings, the bladder worm lodging in the eye and brain as well as in the muscles. When bladder worms lodge in the human brain they may produce epilepsy. It is highly important, therefore, to prevent this dangerous human infestation by a rigid adherence to sanitary disposal of human excreta on farms and in rural communities. Proper sanitation will remove the danger of infecting human beings as well as swine.

THE THIN-NECKED BLADDER WORM

The thin-necked bladder worm, *Taenia hydatigena*, is embedded in the liver, attached to the abdominal organs, or free in the abdominal cavity of cattle and sheep as well as swine. It is usually about 1 inch in diameter but may be much larger (fig. 6).

Life history.—The life history is similar to that of the pork tapeworm, except that the dog harbors the adult tapeworm. Dogs become infested as a result of swallowing live bladder worms. Hogs, in turn, become infested as a result of swallowing the eggs or tapeworm segments eliminated with the droppings of infested dogs which run over hog pastures and lots.

Damage.—Infestations of swine with the thin-necked bladder worm cannot be diagnosed during life. A light infestation produces little, if any, injury; heavy infestations are said to be fatal to young animals.

Treatment.—There is no known practical method for removing the

2530-ZOOL.

FIGURE 8.—Hydatid lesions (white spots) on the surface of a swine liver.

thin-necked bladder worm from swine or destroying it in the living animals.

Prevention.—Destruction of bladder worms in swine carcasses, however, is an important method of controlling the spread of this parasite. Under Federal, State, or local meat inspection, the bladder worms and affected parts are condemned and tanked. When swine are killed on the farm or in country slaughterhouses having no inspection, there is danger that parts affected with bladder worms may be thrown to the dogs or, because of improper disposal of offal, may become accessible to dogs. Proper disposal of inedible parts of swine killed on farms, supervision over country slaughterhouses, deep burial, or preferably burning, of swine and other host animals that die on farms, will prevent infestation of dogs. Proper attention to dogs to prevent their roaming over pastures and lots, and regular treatment for removal of tapeworms, will prevent the spread of this infestation to swine.

THE HYDATID

Hydatids, *Echinococcus granulosus*, are bladder worms found principally in the liver and lungs of swine, but also in practically every organ of the body. They vary in size and shape and may attain the size of a child's head. Those in swine livers (fig. 8) range downward from the size of an orange. The bladder is filled with a clear fluid containing minute objects resembling grains of sand. These are the brood capsules which contain multiple heads, each head capable of giving rise to a tapeworm in the intestine of a dog, cat, or other carnivorous host animal. The primary bladder worm may develop other bladder worms on the inside or the outside, the daughter

bladder worms being attached or unattached to the mother bladder worm and each daughter bladder worm developing its own brood capsules.

Life history (fig. 9).—The segments containing eggs eliminated by adult tapeworms in the intestine of a dog, or other carnivore, pass out with the droppings to contaminate the soil, feed, and water with which they come in contact. Infested dogs that run over hog lots and pastures may leave behind them tapeworm eggs, each capable of producing a hydatid cyst in the liver or other organ of a susceptible animal that eats it.

Hogs acquire hydatids as a result of swallowing feed or water contaminated with the tapeworm eggs or by rooting in contaminated soil. The tapeworm eggs hatch in the digestive tract of swine and reach the liver and other organs through the blood. Presumably the newly hatched larvae in the alimentary canal penetrate its wall and get into the blood stream. The larvae are thus distributed to various organs, in which they settle down and develop into hydatids. Dogs, in turn, become infested as a result of eating infested offal from slaughterhouses or the carcasses of dead animals left lying in

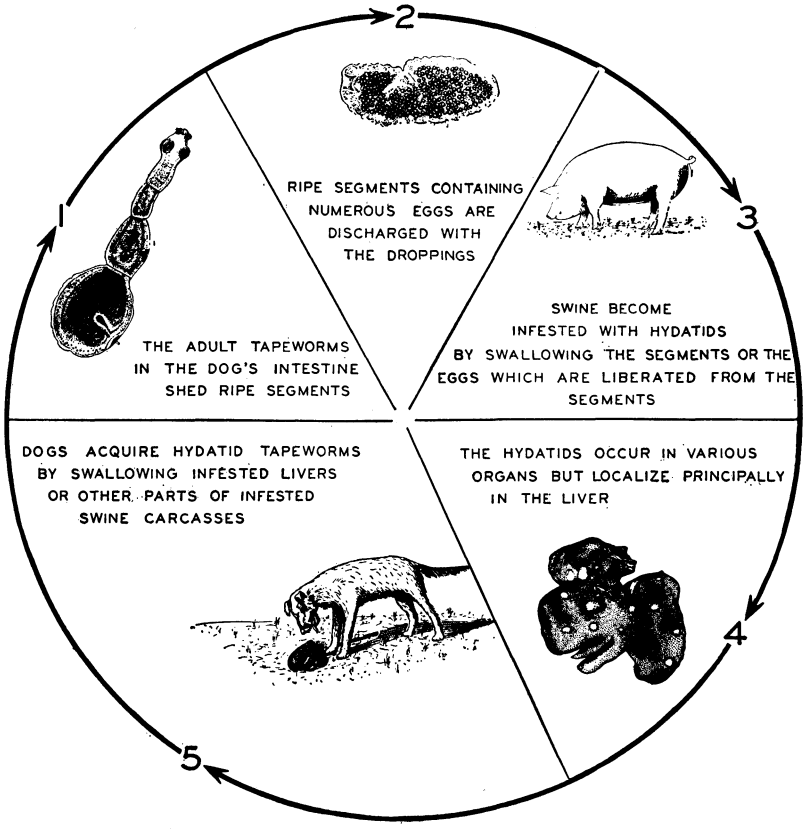


FIGURE 9.—Life cycle of hydatid tapeworm.

pastures or lots. The tapeworm that develops in the dog is only about one-fifth of an inch long and consists of only three to five segments.

Damage.—No distinctive symptoms associated with hydatid infestation of swine have been noted. Considering the size of hydatid cysts and their presence in vital organs, these parasites must be considered decidedly harmful. By sheer weight the cysts would injure the organs which they infest and would interfere seriously with the functions of the affected parts.

Prevention.—Follow the procedures for controlling the thin-necked bladder worm (p. 12). Stopping the wandering of dogs over pastures and lots is particularly important; hydatids are far more injurious to swine than the thin-necked bladder worms. Periodic treatment of dogs to remove tapeworms is another measure essential for controlling hydatids. Not only hogs, but also sheep, cattle, horses, and human beings, are susceptible to hydatids. In human beings hydatids are highly dangerous parasites; an infestation with them necessitates a very serious surgical operation. Preventive measures taken to control hydatids in hogs and other farm animals will aid materially in controlling this infestation in human beings.

ROUNDWORMS

Roundworms are relatively slender, cylindrical worms, attenuated at both ends. In swine they range widely in size, the smallest mature worms being about one-sixth of an inch long and as thin as the finest silk thread, and the largest 10 or more inches long and as thick as, or thicker than, an ordinary lead pencil. Roundworms exist in various places inside and outside the digestive tract; some wander in the larval or adult stage to places where they become trapped in one way or another. Some of the roundworms, such as the stomach worm, are named for the organ in which they are principally found.

The roundworms discussed in this bulletin, with the exception of trichinae, reproduce by means of eggs expelled by the worms. The eggs, which can be seen only with the aid of a microscope, are passed with the droppings (urine in the case of kidney-worm eggs) of infested swine. The eggs of certain roundworms hatch on the ground, and the newly emerged worms, larvae, must undergo their early development on soil or on pastures before they can infest swine; the free-living stages are too small to be seen with the naked eye. The eggs of other species develop to the infective stage without hatching. Those of still other species develop to the infective larval stage only if they are swallowed by intermediate hosts, usually insects or earthworms. Hogs that swallow the infested intermediate host become infested.

STOMACH WORMS

Swine harbor three species of stomach worms. The red stomach worm, *Hyostrongylus rubidus*, is a small, delicate, reddish, threadlike worm, normally one-fifth to one-third of an inch long and one two-hundred-and-fiftieth of an inch thick. These worms are transmitted from infested hogs to young pigs through larvae which hatch, on pastures and on lots, from eggs deposited by the worms in the stomach. The eggs are eliminated with the droppings of swine, hatch on pas-

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tures and on bare soil, and develop to the infective stage in a few days, under favorable conditions. Hogs become infested with red stomach worms by swallowing feed or water contaminated with the infective larvae.

The thick stomach worm of swine (fig. 7) may be either of two species, *Ascarops strongylina* or *Physocephalus sexalatus*. These worms look very much alike. Both are whitish or reddish, between a fifth of an inch and an inch long, and about an eightieth of an inch thick. The thick stomach worms of hogs are transmitted by various species of dung beetles which feed and breed in swine manure. The beetles swallow the worm eggs with the manure of infested swine and transmit the parasites when swine eat the infested beetles.

Damage.—Stomach worms contribute generally to the emaciation and digestive disturbances that characterize infestation with parasites. The presence of these worms in the stomach is usually associated with a catarrhal condition of the stomach wall. The presence of thick stomach worms, in particular, is usually associated with a thick, mucuslike false membrane of the stomach wall, the worms being between this false membrane and the stomach wall proper. Young worms may penetrate the stomach wall. These conditions interfere, no doubt, with the process of digestion.

Treatment.—Carbon disulfide, administered at the rate of 2 to 2½ fluid drams (8 to 10 cubic centimeters) per 100 pounds of live weight, is effective in removing the red stomach worm from swine and has been recommended also for the removal of the thick stomach worm. The drug may be administered in capsules or by stomach tube. Food should be withheld for 18 to 24 hours before treatment, as the presence of food in the stomach interferes with the action of the drug and tends to reduce the value of the treatment.

Sodium fluoride (p. 21) also has given good results against the thick stomach worm.

Control.—The swine-sanitation system, including the modification for kidney-worm control (p. 23), will help to control the red stomach worm. Sanitation in general, with emphasis on the avoidance of old hog lots, straw piles, and permanent pastures in which dung beetles are most prevalent, should prove helpful in controlling these pests.

THE INTESTINAL THREADWORM

Intestinal threadworms, *Strongyloides ransomi*, are especially common in pigs during the suckling stage and persist, usually in smaller numbers, for a long time after weaning. The adult parasites, all of which are females, live in the small intestine. These worms are very fine, delicate, whitish creatures, about one-sixth of an inch long and about one-thirtieth of an inch wide.

Life history.—The eggs produced by the worms in the intestine are eliminated with the droppings. On bare soil or on pastures, the eggs hatch within a few hours, under favorable conditions, and the larvae which issue from the eggshells follow one of two courses of development. Some larvae develop directly to a stage that is infective to swine. Others develop on the ground into male and female worms. These worms mate, and the females produce eggs which hatch on the ground; the young worms issuing from these eggs develop to a stage

that is infective to swine. In either case, the net result is the development of young worms capable of entering the bodies of pigs.

Pigs become infected from eating feed contaminated with the infective larvae and also as a result of the penetration of the larvae through their skin (p. 33).

Damage.—Young pigs appear to be more heavily infested with these parasites than grown hogs. Young pigs harboring massive infestations of threadworms suffer from diarrhea and loss of appetite, fail to grow normally, and may die. Threadworm larvae wander extensively in the bodies of hogs, causing severe damage to muscles and vital organs. Pigs, and sows in a weakened condition from suckling their litters, may die as a result of larval invasion of the heart, brain, spinal cord, and other organs.

Treatment.—No treatment based on thorough tests has yet been devised for the removal of intestinal threadworms from swine.

Prevention.—Keep sows with pigs in clean quarters with clean bedding. Avoid permanent hog lots and pastures.

THE LARGE INTESTINAL ROUNDWORM OR ASCARID

The large intestinal roundworm, *Ascaris suis*, is a large, thick, yellow or pink worm, about the size of an ordinary lead pencil (fig. 10). The adult parasites normally live in the small intestine; wandering adults may also move into the stomach, the lower portion of the alimentary canal, the bile ducts of the liver, the gall bladder, and other parts of the body which have channels of communication with the gut. The young worms migrate through the blood stream, the liver, lungs, and other organs and tissues.

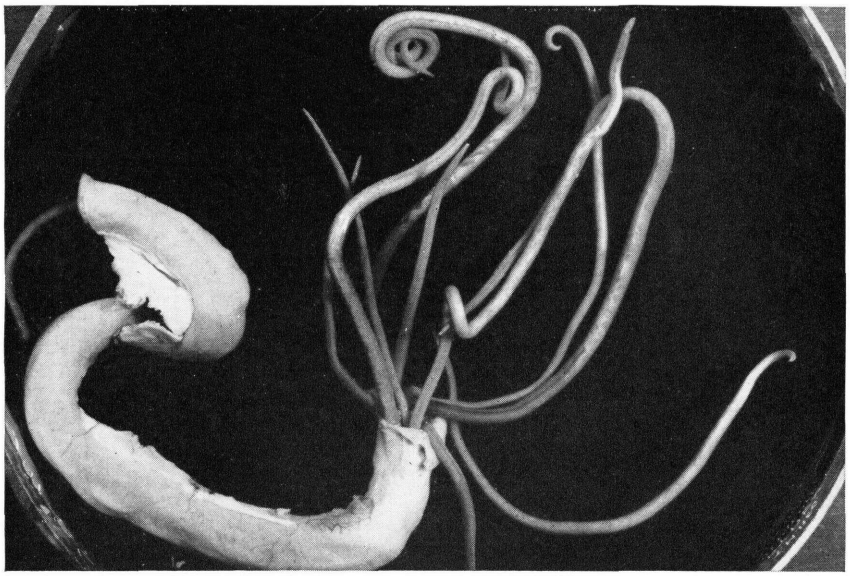

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FIGURE 10.—Ascarids infesting the small intestine of a pig. Some of the worms are protruding from, and a few are completely outside the intestine. (One-half natural size.)

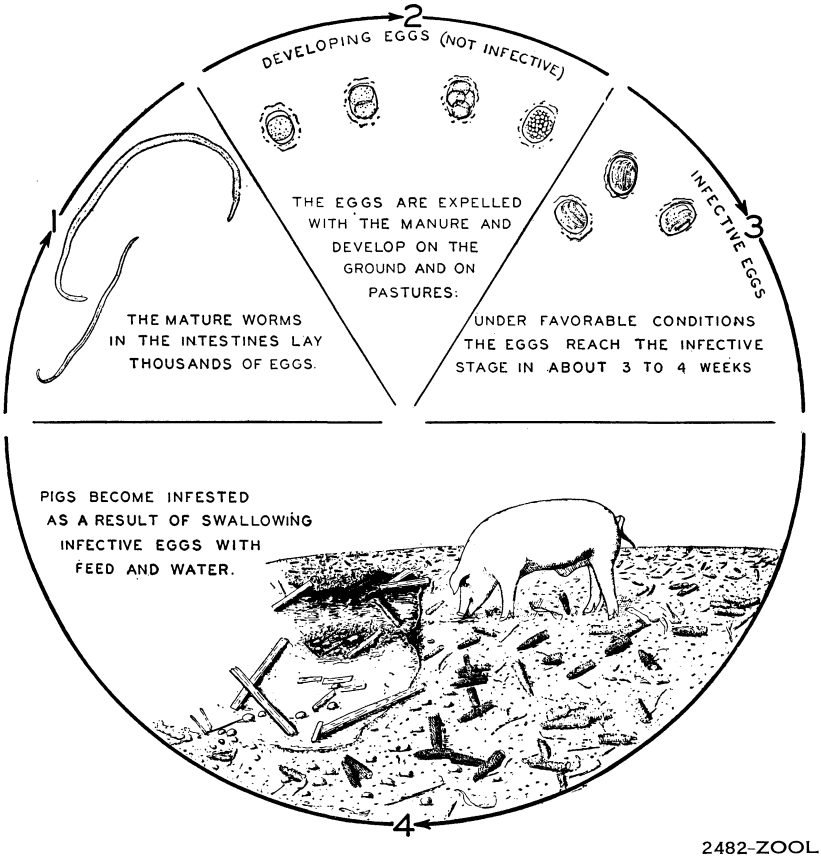

FIGURE 11.—Life cycle of swine ascarid.

Life history (fig. 11).—The adult females produce thousands of eggs daily. It has been estimated that a single full-grown female worm in the intestine of a hog may contain between 26 and 27 million eggs. The eggs are eliminated from the hog's intestine with the droppings and are not infective until they have undergone development in the open. Under favorable conditions of temperature and moisture, the eggs reach the infective stage in 3 to 4 weeks; under unfavorable conditions, such as low temperatures and lack of moisture, development of the egg may take several months. By the time the eggs have reached the infective stage, a tiny worm, already undergoing a molt, is in the eggshell.

Pigs become infested with ascarids by swallowing the infective eggs with feed or water. Ascarid eggs are abundant on hog lots, pastures, and other places contaminated with the droppings of infested hogs. The young worms present in the eggshells become free in the pigs' intestines. They penetrate the wall of the intestine and travel in the blood stream to the liver, and from the liver to the lungs. In the lungs the worms leave the small blood vessels and get into the air spaces. From the air spaces in the lungs they travel upward along the

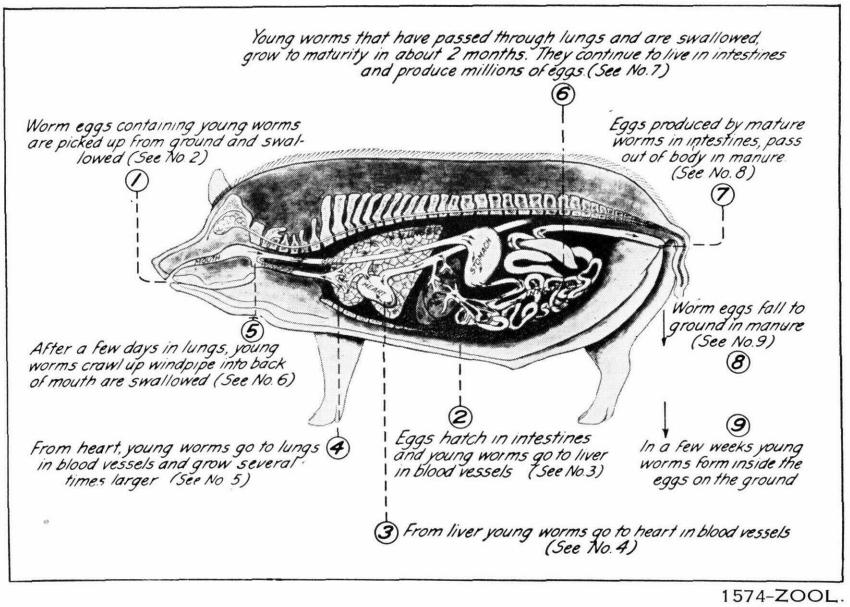

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FIGURE 12.—The roundworm's journey through the pig.

branches of the windpipe and in the windpipe proper, reach the back of the mouth, and are swallowed. On getting back into the intestine, they settle down and grow to egg-laying maturity in 2 to 2½ months. If many young worms make their curious roundabout journey (fig. 12) at the same time, the resulting injury to the lungs is likely to be very serious and may prove fatal to very young pigs.

Damage.—Ascarids in the intestine may produce digestive disturbances and a capricious appetite, retard growth and development, and interfere with the well-being of pigs in other ways. In exceptional cases, particularly when pigs are on an inadequate diet, infested animals may become anemic and suffer from colic, in extreme cases from convulsions. During the migration of numerous young ascarids through the lungs, pigs have difficulty in breathing and may die of pneumonia. Probably many, if not most, cases of thumps in young pigs are caused by ascarid migrations through the lungs, but other causes of thumping must not be overlooked. Pigs that survive a severe infestation of the lungs with ascarid larvae may not recover fully and often fail to grow and develop at a normal rate. Pigs are far more susceptible to ascarids than grown hogs, and very young pigs suffer seriously from the effects of these parasites.

Although damage to the liver and lungs by the migrating larvae heals, as a rule, the liver is sometimes permanently affected by the massive migration of young worms. Repair to the damage results in numerous scars, the entire surface of the liver becoming peppered with whitish areas (fig. 13). In some lots of hogs as many as 35 percent of the livers have been thus affected.

Recent evidence indicates that ascarid larvae may intensify the pathogenicity of diseases, such as virus pig pneumonia, which are already present in the pig.

Treatment.—One of the most satisfactory treatments for the removal of ascarids from swine consists in feeding the pigs for 1 day on a mixture containing from ¾ to 1 percent sodium fluoride (technical grade) in dry ground feed. For large numbers of pigs, a satisfactory mixture may be prepared by thoroughly mixing 1 pound of the chemical with 100 pounds of feed. Smaller quantities may be prepared by mixing the materials at the rate of 1½ ounces of sodium fluoride to 10 pounds of feed. It is emphasized that the chemical should be mixed only with dry ground feed. If the animals requiring treatment are unaccustomed to this type of ration, keep them on such nonmedicated feed for 1 or 2 days before being dosed.

It is neither necessary nor desirable to fast the animals before treatment, but slight underfeeding is advisable on the day before dosing. On the day of treatment, give the medicated feed in the morning in somewhat smaller amounts than the animals normally consume in 1 day; usually from two-thirds to three-fourths of the normal quantity is sufficient. The next morning, mix regular dry ground feed with any medicated feed that remains; continue customary feeding thereafter.

The number of animals that may be treated in a group is generally limited only by available trough space. The pigs in the group, however, should be reasonably uniform in size and vigor, although some latitude is permissible. Administering the drug in feed at concentrations of 0.75 to 1 percent seems to afford some natural protection against poisoning on account of a self-limited consumption and because of the vomiting that follows occasional over-indulgence. Sodium fluoride is an intestinal irritant and the amount given in these feed mixtures appears to afford sufficient stimulus to cause effective

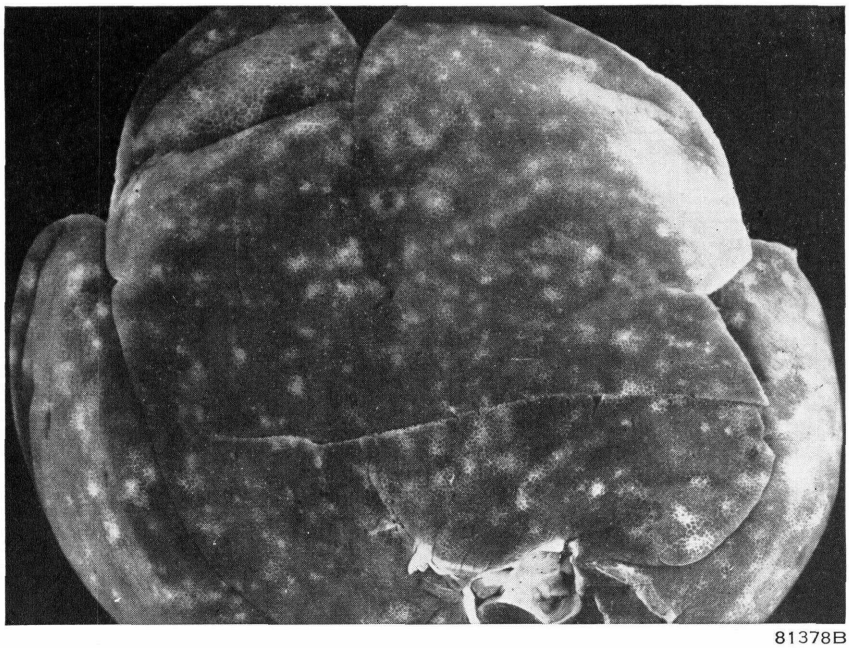

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FIGURE 13.—Scars produced by migrating ascarid larvae in a swine liver.

elimination. Therefore the administration of a purgative in connection with the treatment is unnecessary and inadvisable.

Ordinarily, growing pigs may be expected to benefit from two treatments before they reach marketable age and weight. Give the first treatment when the pigs are 7 to 8 weeks old, or at about weaning time, and the second 2 or 3 months later. The treatment probably should not be given to pregnant sows, particularly during the last half of the gestation period, to nursing sows, or to any animals that show evidence of gastroenteritis.

Sodium fluoride is poisonous. Containers of the chemical should be conspicuously labeled and stored out of reach of children, household pets, and individuals who are not familiar with its poisonous nature. The technical grade that is ordinarily available for civilian use is tinted to avoid risk of confusing it with foodstuffs.

Alternative treatments, namely, cadmium oxide, cadmium anthranilate, piperazine, and hygromycin, have been developed within recent years for the control of ascarids and, in some cases, other worm parasites of swine. In every case, commercial products containing these chemicals should be used strictly in accordance with the specific directions that accompany them.

The cadmium compounds are admixed with the regular ration and given free choice for three consecutive days. These compounds are effective against the large intestinal roundworm but show no action against other parasite species.

Piperazine is usually given in feed or drinking water to groups of pigs, but it may be administered also in capsules or by stomach tube or dose syringe to individual animals. In appropriate dosages, the chemical exhibits marked anthelmintic action against nodular worms as well as large roundworms.

Hygromycin is given to growing pigs for five or more weeks as a component of the regular ration. This material is reported to be effective in the control of large roundworms, nodular worms, whipworms, and perhaps other worm parasites.

Because cadmium has a tendency to accumulate, at least temporarily, in edible tissues of treated swine, the animals should not be slaughtered within less than 30 days after medication. For this reason also, it is generally recommended that the cadmium treatment should be given only once during the lifetime of pigs to be marketed. There is no evidence that piperazine or hygromycin are retained in edible tissues of treated animals for any appreciable period.

Phenothiazine is no more effective than sodium fluoride for the control of ascarids, but it has some advantages as a treatment for the removal of nodular worms. Satisfactory results may be obtained with a dose rate of 1 gram of phenothiazine for each 5 pounds of live weight for pigs weighing up to 50 pounds; 1 additional gram should be given for each additional 10 pounds of body weight, with a maximum dose of 30 grams. The drug may be administered in the

feed if the pigs are in a pen that is familiar to them and if space at the trough is sufficient for all the animals. The pigs should be reasonably uniform in size and sufficiently hungry to consume all the medicated feed in a short time. The drug should be mixed with from three to four times its weight of dry ground feed. If the pigs are accustomed to feeding on slops, the medicated mixture may be made into a thick mass, but not into a thin slop. Phenothiazine sometimes produces paralysis and other toxic symptoms, especially in very young animals.

Phenothiazine may be administered to swine in capsules if the operator is sufficiently skilled to avoid lodging the capsules in the pharyngeal pouches.

If practical, pigs should be confined for a few days after anthelmintic treatment in a pen not intended for their permanent use. Treatment may be repeated in 10 to 14 days, if necessary, to remove any worms not affected by the first treatment.

Control.—Control of ascarid infestation in swine can be accomplished successfully by following the sanitation system of swine management developed by the U. S. Department of Agriculture as a result of scientific investigations carried out in cooperation with farmers. The swine sanitation system is the basis on which control measures for all swine parasites should be undertaken. The system as a whole requires certain modifications here and there, in order to adapt it to the control of parasites other than ascarids. Modifications already worked out in detail for kidney worms are discussed on page 35.

Swine-Sanitation System

Before farrowing time thoroughly clean the farrowing pens, which should be of sanitary construction, by removing all manure and other litter and scrubbing the floors, walls, troughs, and guard rails with hot water and lye. The water should be very hot and should be used liberally in order to destroy the worm eggs; the lye helps to remove dirt. If the farrowing pens are not artificially heated, the cleaning should be done in the fall before freezing weather, and the pens should be kept closed until used by sows and pigs.

Place the sows in the clean pens a few days before farrowing, but not until the mud and dirt on their skins have been removed by careful washing with soap and warm water. Wash the udders particularly well. No part of the sows' bodies, including the feet, should be overlooked in the cleansing process. The mud and filth adhering to the sows' bodies, udders, and feet are likely to contain numerous worm eggs and disease germs, so that the newborn pigs are likely to swallow infective material with the first few mouthfuls of milk.

Do not allow the sows and pigs out of the farrowing pens until they are hauled to a pasture which has been prepared especially for them. They may be moved to the pasture, in from a few days to 2 weeks, in a small truck (fig. 14). Clean the truck bed and put down a layer of clean straw. Then load the sow and pigs directly to the truck from the farrowing pen. An essential feature of the

system is the avoidance of old hog lots and permanent pastures. Hence the pasture to which the sows and pigs are moved should be one that has been under cultivation and has been sown to a suitable forage crop, preferably a leguminous crop. The pasture should be provided with individual shelter houses for the sows and their litters. A safe, clean water supply should be provided. No other hogs should have access to this pasture, nor should the pigs be allowed to run back from the pasture to the barnyard or hogyard or to any other place contaminated with the manure of other hogs. Failure to follow this precaution often has virtually nullified the benefits of the entire system. When it becomes necessary to move the pigs after weaning to another pasture, follow the same precautions in arrangements for a clean temporary pasture. This pasture should not have been occupied by hogs previously, and should have good shelter houses and a safe water

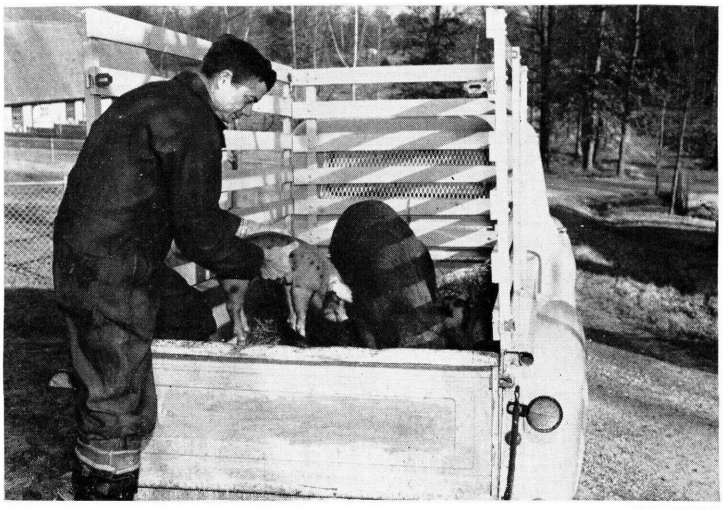

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FIGURE 14.—A small truck for hauling the sow and pigs from the farrowing pen to the pasture.

supply. The safe procedure is to keep the pigs on clean pastures, under conditions which will bar access to dirty hog lots, until they are ready for market.

The swine-sanitation system was originally developed for spring pigs farrowed in the Northern and Central States. For fall pigs farrowed in those States, the arrangements may be modified as follows:

The permanent farrowing house need not be used. If the sows have been running on pasture and are not incrusted with mud and filth, they may be transferred directly, without washing, to the special pasture, and allowed to farrow in the individual houses on the pasture. This modification is applicable to the South for both spring and fall farrowing and is commonly followed in many Southern States. In the South simple, inexpensive A-type houses are provided on the pasture for the sow and her litter (fig. 15).

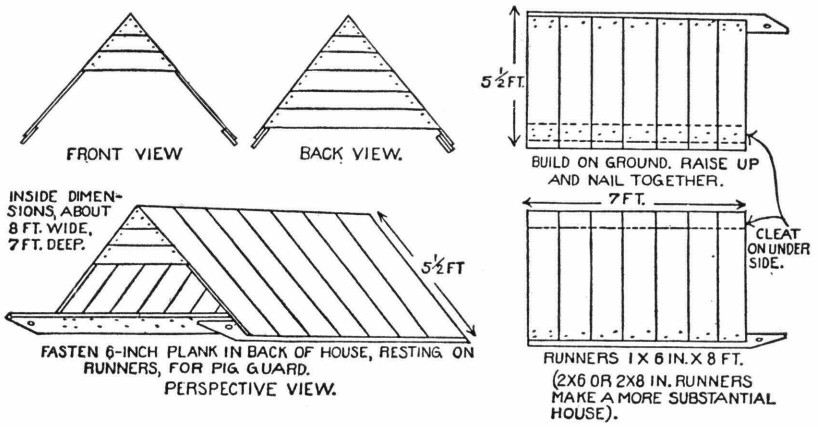

FIGURE 15.—Individual portable farrowing house suitable for use in the South.

By following the swine-sanitation system the hog grower can reduce the cost of producing his pig crop. With due attention to all the steps in the system, the number of sows required for a given pig crop can be reduced by as much as 33 percent. Moreover, pigs raised under the sanitation system are noticeably uniform in size (fig. 16), runtiness being greatly reduced, and the time required for raising the animals to market size can be shortened by from 4 to 8 weeks. This effects a saving in feed and care and reduces the risk of loss from infectious diseases because of the shorter holding period.

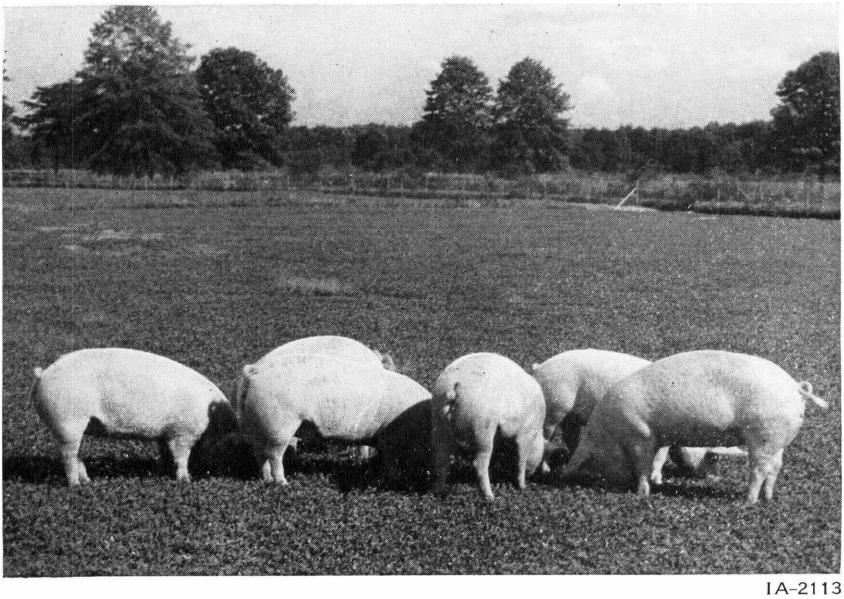

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FIGURE 16.—Pigs raised under the sanitation system, uniform in size and quality at 6 months of age.

It is important to remember that hog-cholera control by approved methods should be practiced along with sanitation.

The ascarid that infects human beings is closely related to, if not identical with, the pig roundworm. In man this parasite undergoes migrations similar to those in the pig. Although it has not yet been established conclusively that the pig roundworm will develop in the human intestine, it has been shown that the larvae of the pig roundworm will migrate to the lungs of human beings and produce serious damage. Children, in particular, are likely to pick up ascarid eggs while playing in areas to which pigs have access, especially through putting soiled fingers in the mouth or eating fruit that has fallen on the ground. A strict adherence to the sanitation system of swine

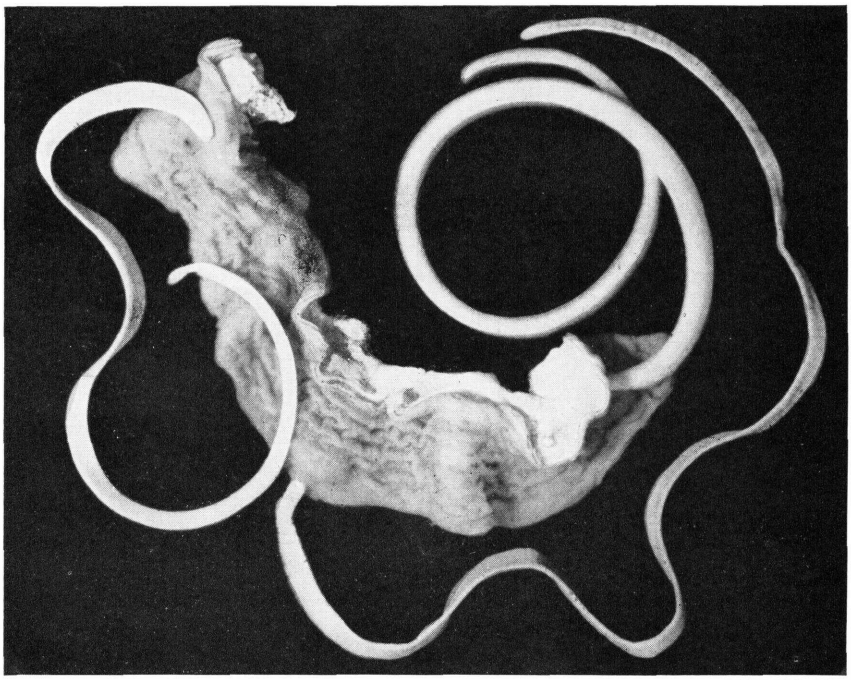

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FIGURE 17.—Thorn-headed worms attached to a small portion of a hog's intestine. (One-half natural size.)

husbandry involves keeping pigs on well-fenced pastures. This precaution is a human-health safeguard, as well as a sound animal-husbandry practice.

THE THORN-HEADED WORM

Thorn-headed worms, *Macracanthorhynchus hirudinaceus*, are milk white to bluish and cylindrical, the largest being about the size of a lead pencil. The head is provided with a spiny proboscis (snout), by means of which the worm becomes firmly attached to the wall of the gut (fig. 17). The attachment of the worm is so firm that it requires some effort to detach one from its hold.

Life history (fig. 18).—The adult female worms produce numerous eggs which pass out with the manure of the infected animals. White grubs—larvae of May beetles, or June bugs—eat the eggs along with swine manure or with soil contaminated with the manure of infested swine. The eggs hatch in the bodies of the grubs and develop to a stage that is infective to swine. Pigs obtain and swallow the grubs by rooting in the soil that holds them. The young worms escape from the bodies of the grubs as a result of the process of digestion in the

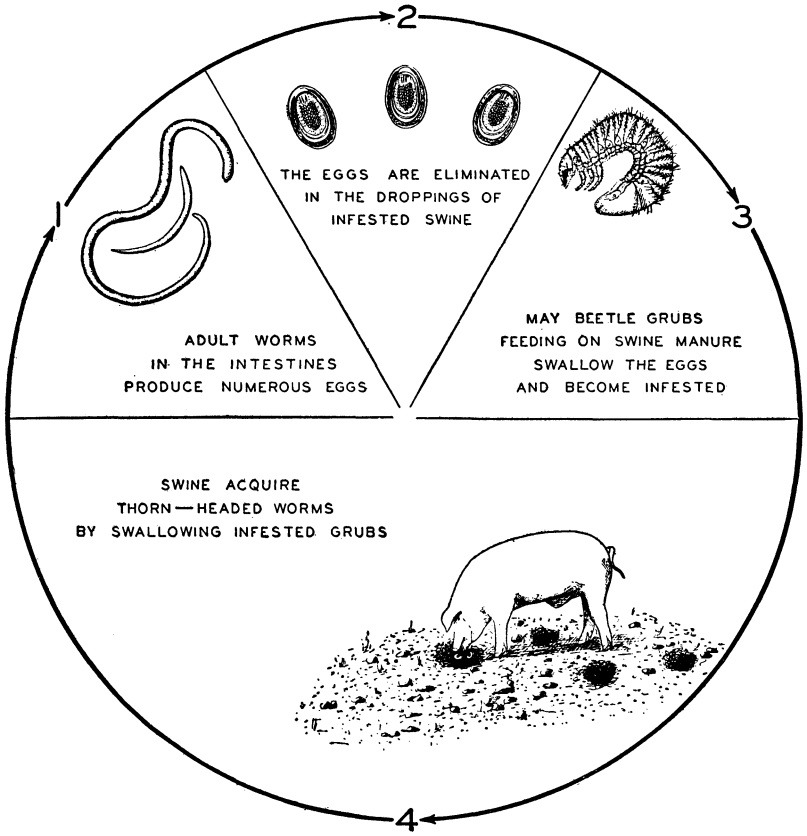

FIGURE 18.—Life cycle of the thorn-headed worm.

pig's stomach or intestines or both, settle down in the intestine, and develop there to egg-laying maturity in about 8 weeks.

Damage.—No special symptoms have been attributed to infestation with thorn-headed worms, although these parasites are decidedly injurious. At the place of attachment to the intestinal wall a swelling or nodule appears; this is visible on the outer coat of the intestinal wall. Sometimes the injury is so deep that the intestine is perforated, which causes peritonitis, an inflammation of the delicate lining of the abdominal cavity. This condition is fraught with serious, often fatal, consequences. These worms contribute also to the general unthrifti-

ness that is nearly always associated with parasitic infestation and, in exceptional cases, may produce the serious condition already noted.

Treatment.—Various drugs known to be effective in removing certain parasites from swine and other domesticated animals have not proved very effective in removing thorn-headed worms. In the absence of effective medicinal treatment, control measures constitute the only hope at present of keeping swine free from thorn-headed worms.

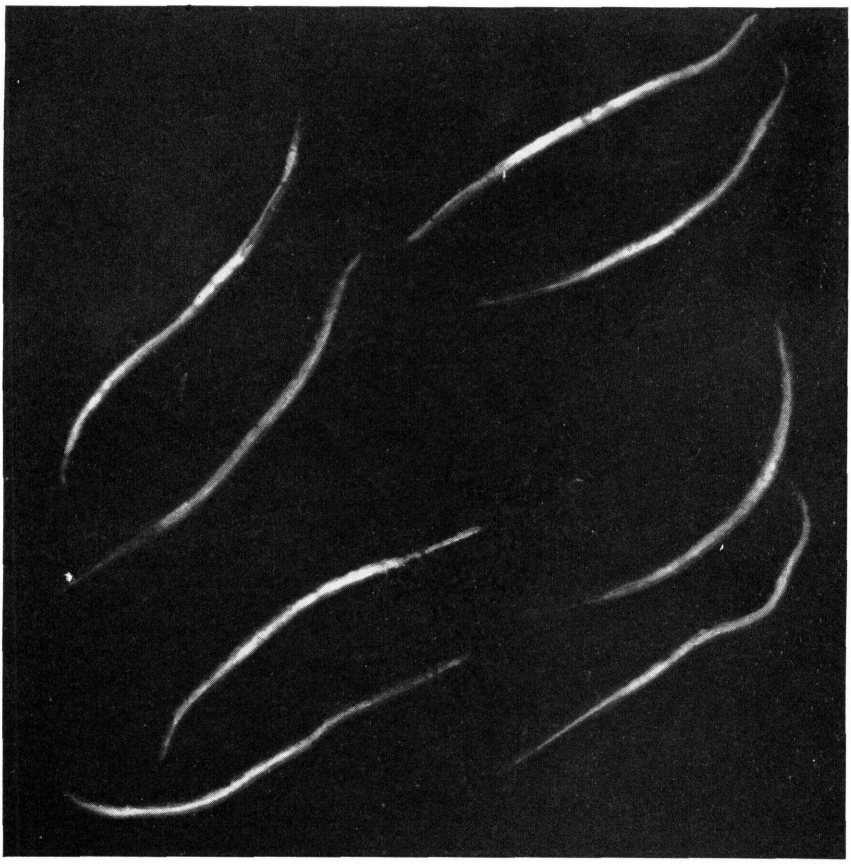

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FIGURE 19.—Swine nodular worms. (Slightly enlarged.)

Control.—Ringing the noses of swine tends to keep them from rooting and so swallowing infested grubs. Sanitation, especially the avoidance of old hog lots, straw piles, and permanent pastures, is an additional safeguard.

NODULAR WORMS

Three species of nodular worms are common in swine in this country. The common nodular worm of swine, *Oesophagostomum dentatum*, is found in practically all parts of this country; the long-tailed nodular

worm, *O. longicaudum*, and the short-tailed nodular worm, *O. brevicaudum*, mostly in the South. Adult nodular worms in the lumen (cavity) of the cecum and colon are slender, whitish, or grayish-brown worms, from about one-third to slightly over one-half an inch long by one-hundredth of an inch wide (fig. 19). These parasites pass their immature stages in the walls of the cecum and colon.

Life history.—The female worms discharge the eggs into the lumen of the intestine. The eggs reach the outside with the droppings. On bare soil and on pastures the eggs develop rapidly, under favorable conditions, and hatch in a day or so. The newly hatched larvae find an abundance of food in their surroundings and undergo two moults in a week or less, under favorable conditions. The larvae retain the skin of the second molt as a loose sheath around the body; at this stage the larvae are capable of infecting susceptible pigs which might happen to swallow them with contaminated feed or water.

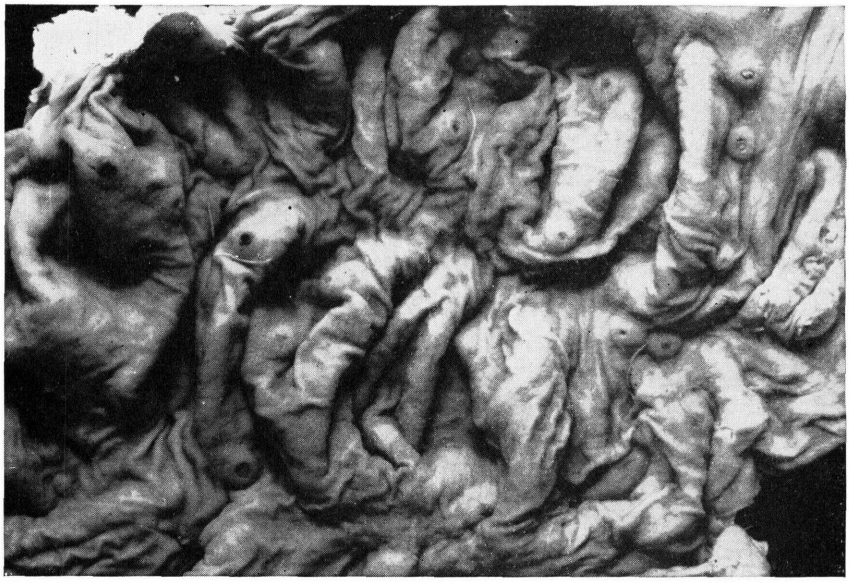

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FIGURE 20.—Nodules and some of the worms that caused them on the inner surface of a pig's large intestine. (Natural size.)

Upon being swallowed by pigs, the larvae at first seek shelter in the wall of the large intestine, which they penetrate. As a result of their invasion the wall of the intestine becomes peppered with nodules (small elevations), each of which contains a young developing worm (fig. 20). Sooner or later the worms reach the stage at which they are ready to reenter the lumen of the intestine. This transfer is effected by a migration of the worms, the small opening at the summit of the nodule affording an exit for the parasites. The worms in the lumen of the intestine attain their full growth and sexual maturity about 2 months from the time the larvae were taken into the body.

Damage.—Nodular-worm infestation, a contributing cause of unthriftiness in pigs, is characterized by weakness, constipation or diar-

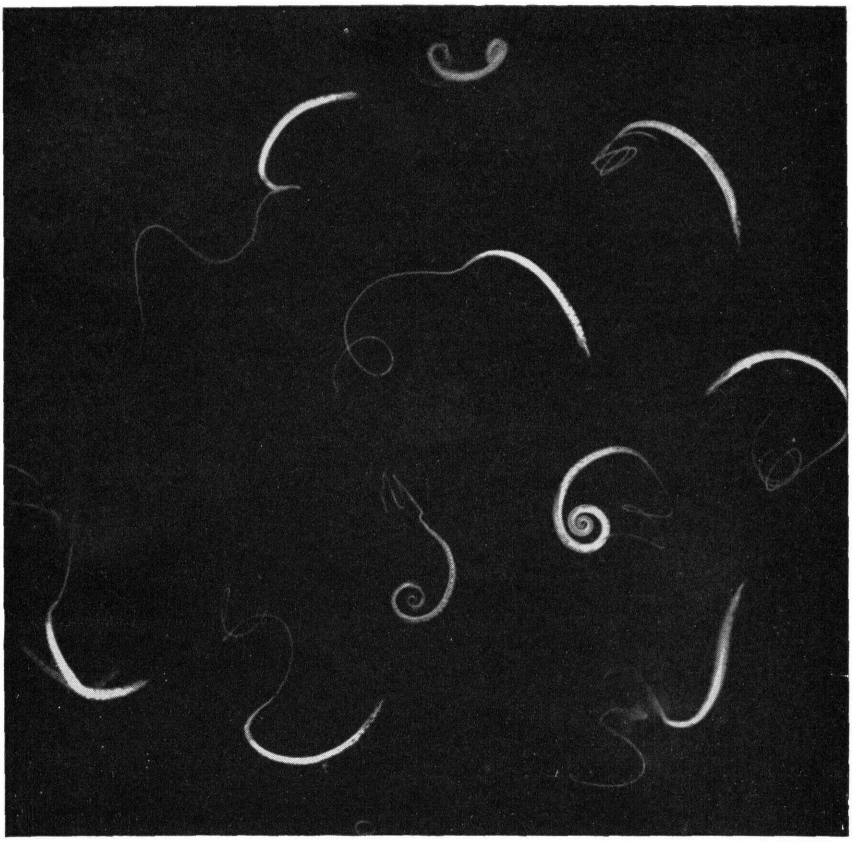

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FIGURE 21.—Swine whipworms removed from the intestine.

rhea, anemia, and other symptoms of parasitism in swine. Swine infested with nodular worms are usually infested also with other parasites, and it is difficult, therefore, if not impossible, to assign a specific clinical significance to nodular worms alone. The nodules resulting from infestation with the common nodular worm are hardly larger than pinheads, as a rule; those produced by the long-tailed variety are much larger, conspicuously raised above the surface of the inner lining of the wall of the intestine, frequently highly inflamed, and sometimes complicated by secondary bacterial infection. Highly inflamed ulcerated nodules sometimes result from nodular-worm lesions, and this, in turn, must contribute in no small measure to unthriftiness of the pigs. An ulcer is an open sore containing dead tissue, bacteria, and pus. Aside from possible absorption of toxic material from ulcerated nodules, the danger of bacterial infection spreading from the nodule, with possible serious consequences, adds a further complication to this parasitic invasion.

Treatment.—Until the discovery of phenothiazine as an anthelmintic there was no fully effective method for removing nodular worms from swine. Given to swine in adequate dosages (p. 22), one

treatment with phenothiazine will remove more than 90 percent of all nodular worms in the treated animals. Alternative treatments, namely, piperazine and hygromycin are discussed on page 21.

Control.—Follow the swine-sanitation system, with the modifications designed for kidney-worm control. Move A-type farrowing houses at frequent intervals—at least once a week during warm weather—so that the larvae on the soil shaded by the houses may be killed by sunlight and drying. Use only movable sun shelters; otherwise, nodular worm larvae will accumulate in places shaded by the shelters. Farrowing houses can serve as sun shelters if a door is provided at the back of each house; opening this door insures free circulation of air. Good feeding is an aid in the control of these and other parasites. Well-fed pigs not only have better resistance to the effects of parasites of all kinds, but also do less searching and rooting for feed in trash and litter; foraging and rooting, pronounced habits in poorly fed hogs, result, as a rule, in heavy parasitic infestation.

WHIPWORMS

Whipworms of swine, *Trichuris suis*, are from 1⅓ to 2 inches long, the body consisting of a slender part followed by a relatively thick part. The slender portion of the worm bearing the head at the tip is about twice as long as the thick portion (fig. 21). The worms live in the cecum and colon, their minute heads rather deeply embedded in the lining of the large intestine (fig. 22).

Life history.—The adult worms in the large intestine of swine produce microscopic lemon-shaped eggs that are passed with the droppings. Once outside the body, the eggs develop to the infective stage, development requiring a month or longer under favorable conditions. High summer temperatures speed development of the

2522-ZOOL.

FIGURE 22.—Whipworms attached to the inner surface of a hog's cecum. (Natural size.)

eggs; low temperatures retard it for several months. Pigs become infested as a result of swallowing the infective eggs with feed or water or of rooting in soil contaminated with the eggs. So far as is known, the newly hatched larvae settle down in the large intestine, where they develop to maturity in 4 to 5 weeks.

Damage.—If pigs harbor a few or a moderate number of whipworms, they show no symptoms. Massive infestations may cause unthriftiness, weakness, and emaciation; they may even kill a young pig. The attachment of the worms to the wall of the intestine produces an inflammation of the delicate lining.

Treatment.—Hygromycin (p. 21) is reported to be effective in the control of whipworm infections.

Prevention.—The methods recommended for the control of the large intestinal roundworm are also effective in controlling whipworms. The similarity in control measures for the two species of parasites is based on general similarity in life history.

THE SWINE KIDNEY WORM

The full-grown parasite *Stephanurus dentatus* is a thick black-and-white, mottled worm 1 to 2 inches long and one-twentieth to one-tenth of an inch wide (fig. 23). The mature worms live in cysts in the walls of the ureters (slender tubes that connect the kidneys with the bladder) and sometimes in the kidney tissue proper. The incompletely developed worms exist principally in the liver, in various blood vessels, especially those of the liver, free in the abdominal cavity, in fat surrounding the kidneys, embedded in the loin muscles, and in the lungs. Occasionally kidney worms penetrate the spine.

Life history (fig. 24).—The female worms produce large numbers of microscopic eggs. The eggs reach the cavity of the ureters through perforations made by the parasites in the walls of these tubes. From the ureters the eggs move on to the bladder and are discharged to the outside with the urine. Given favorable temperatures, shade,

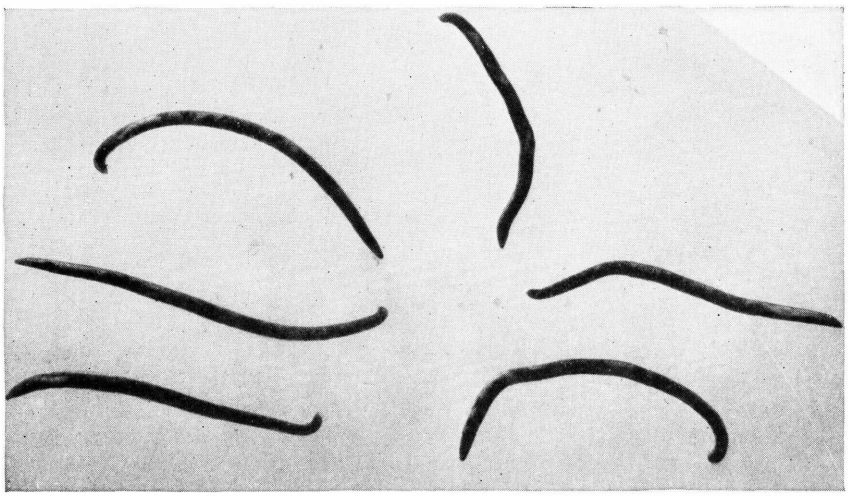

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FIGURE 23.—Swine kidney worms. (Slightly enlarged.)

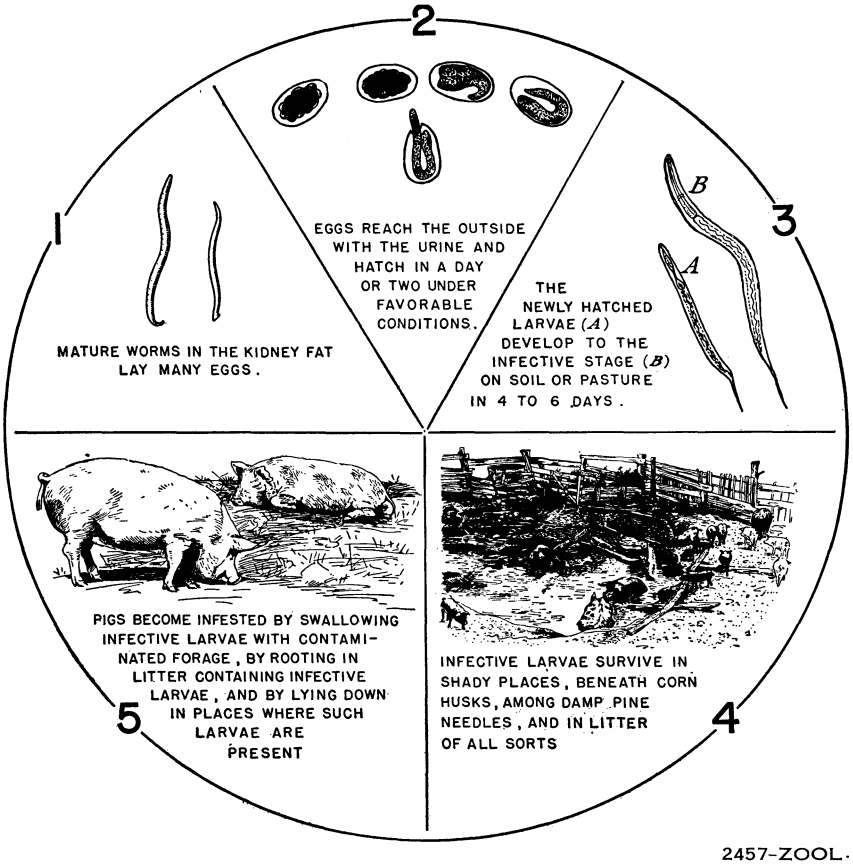

FIGURE 24.—Life cycle of swine kidney worm.

and an adequate supply of moisture, the eggs on bare soil or on pasture hatch in a day or two. There the larvae find abundant nourishment for growth and development. The larvae cannot ordinarily be seen with the naked eye. After casting off the skin once and subsequently reaching a state in which the second larval skin has become loose around the body, the larvae are in the infective stage. Under favorable summer temparatures, this stage is reached 4 or 5 days after hatching. In the cool weather of early spring or late fall the development of the eggs and larvae may be delayed for a week or longer.

The eggs and the larvae offer comparatively little resistance to sunlight, drying, freezing, and other unfavorable influences to which they might be subjected in the open. However, the infective larvae can survive for several weeks in places that provide moisture and shade. On pastures and lots which have abundant shade and some moisture and on lots on which litter of all kinds, including corncobs, corn husks, pine needles, and leaves, is allowed to accumulate, the larvae find ideal conditions for survival. Pigs kept on such contaminated areas have abundant opportunities for swallowing the larvae with contaminated forage, or other feed, or while rooting. Aside from becoming infested

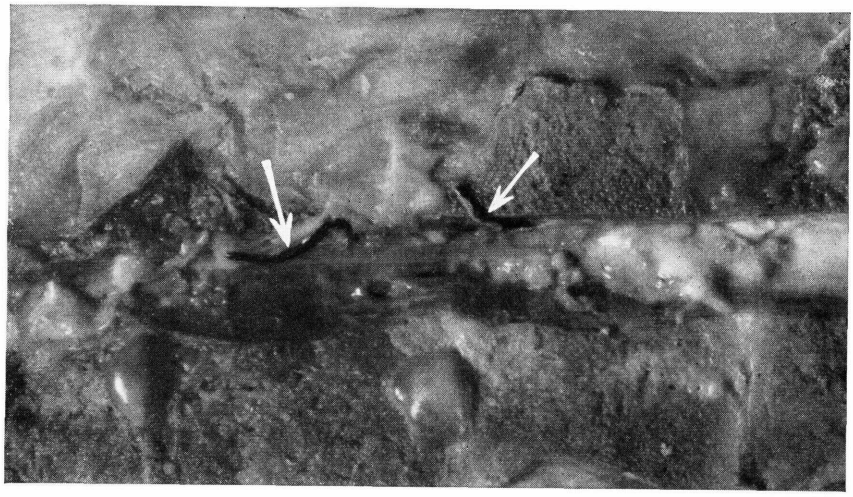

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FIGURE 25.—Kidney worms (indicated by arrow heads) in canal of a hog's spine, split open to show them.

2529-ZOOL.

FIGURE 26.—Scars (whitish areas) produced by kidney worms in a hog's liver.

as a result of swallowing the larvae, pigs can acquire an infestation with kidney worms as a result of lying down on contaminated pastures and lots. The heat of the pig's body stimulates the larvae; and the worms become active and penetrate the pig's skin. Whatever the path of entry into the bodies of pigs, the larvae get into the blood stream and are carried to the liver, lungs, and other internal organs. In the liver, the young worms ultimately bore through the walls of the finer blood vessels, wander in the liver tissue proper, and finally perforate its outer covering (the capsule). This brings the worms to the surface of the liver, over which they move freely. The worms continue their migrations in the abdominal cavity, coming in contact with the abdominal organs. On reaching the kidney fat in the course of their migrations, the worms have little difficulty in pushing into this relatively soft tissue. Some wandering worms get into the loin muscles and into other organs and tissues. Only the worms that reach the kidney fat succeed in migrating to the kidneys and ureters, the walls of which they penetrate. These places afford outlets for the eggs, which are expelled with the urine.

The cycle of development of the kidney worm within the body of a pig up to the time the eggs are ready to be discharged with the urine is slow, requiring 6 months or longer, as a rule. Sooner or later the worms disintegrate, and a whitish mass, consisting of pus, is usually associated with the dead parasites.

Damage.—Aside from general unthriftiness and arrested development, symptoms common to parasitic infestations of all kinds, there are no readily observable symptoms that are especially characteristic of kidney-worm infestation. Infested animals discharge urine which at times contains pus. Posterior paralysis is sometimes due to the penetration of kidney worms into the spine (fig. 25). Most cases of paralysis of the hindquarters, however, are due to other causes.

Parasites as widely distributed throughout the bodies of swine as are kidney worms are bound to produce serious damage in the tissues and organs in which they lodge or with which they come in contact. The principal injury inflicted by kidney worms involves the liver. The worms that migrate through the liver and perforate its capsule produce bloody tracks. As these active lesions heal the damaged liver cells are replaced by hard connective tissue, which produces the grayish-white liver scars characteristic of kidney-worm infestation (fig. 26). These hard areas may be small, circumscribed, and superficial, or they may be large and striking and extend deep into the liver tissue. Pus is commonly associated with the worms that lodge in the liver lesions. Rejection and condemnation of affected livers under meat inspection mean a loss to the producer. The invasion of the loin muscles (fig. 27) necessitates extensive trimming of expensive parts of hog carcasses. When the infestation is excessive and is accompanied by pus, large portions of a carcass—sometimes an entire carcass—must be condemned. These losses are ultimately borne by swine producers, who receive a lower price for hogs because of expected injuries, as well as because of the injuries actually produced by the parasites.

Other important injuries produced by kidney worms involve the following organs; Lungs, which contain hard nodular masses; blood vessels, in which incompletely grown worms produce changes that

interfere with the circulation of the blood; ureters, the walls of which become thickened when the worms lodge in them; kidney fat, which is unfit for rendering into lard; and sometimes the spleen and other organs.

Treatment.—There is no known medicinal treatment for the removal of kidney worms from the blood vessels, liver, kidney fat, kidney proper, lungs, loin muscles, or the other parts of an infested animal's body.

Prevention.—The control of kidney-worm infestation must be based on preventive measures—reducing pasture contamination by observing certain fundamental precautions as to sanitation. This, in turn, involves arrangements which will expose kidney-worm eggs and larvae to the sun, prevent the accumulation of litter and trash on hog pastures, and provide good drainage. This program can be carried out as follows:

Place the pregnant sow, shortly before farrowing, on a well-drained temporary pasture that has been especially prepared by being sown to a suitable forage crop. There should be a bare area, preferably all around the pasture (fig. 28) but at least at one end of it. The bare area at the end should be wide enough (about 30 feet) to accommodate the shelter houses, watering barrel or other supply, creep with self-feeder for the pigs, and a feeding pen for the sow. The remaining bare area should be provided, if possible, but it need not exceed from 3 to 5 feet in width. The entire bare area should be free from trash and litter. Under this arrangement a considerable portion of the sows' urine will be deposited on the bare soil in the wide bare area and along the fences. Kidney-worm eggs eliminated with the urine of infested sows will be deposited, for the most part, where they will perish from exposure to sunlight, heat, and drying. In the absence of vegetation, the top soil is sufficiently dry, except during wet seasons, to destroy life in the eggs and larvae of the worms.

Provide a separate feeding pen for the sows and, at some distance away, a creep with self-feeder for the pigs, thus keeping much infective material away from the pigs. Keep the gate of the sows' feeding pen closed so the pigs cannot get in. Open it only to admit the sows to the feeding pen and to drive them out about an hour after feeding. Sows tend to urinate after feeding, and the kidney-worm eggs deposited with the urine will remain and ultimately perish where the larvae which issue from the eggs will not reach the pigs, provided the drainage from the sows' feeding pen does not reach the pasture.

This entire arrangement, designed to provide effective natural barriers to the development of kidney-worm eggs and larvae, is a practical method of combating one of the most serious parasites which infest swine. Although the sows will also urinate on the pasture and thus deposit eggs there, the plan has the advantage of eliminating a major part of the infective material, thus reducing the degree of infestation to a point where it will do little harm.

Wean pigs as early as is consistent with sound husbandry practices and move the weaned pigs to a clean pasture, preferably one that has not been occupied by pigs for 6 months or longer. The best procedure is to move the pigs to a temporary pasture that has been sown to a forage crop since last being occupied by pigs. This precaution precludes infestation with kidney worms following weaning, provided the

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FIGURE 27.—Kidney-worm invasion of a hog's loin muscles cut open to reveal the worms. (Natural size.)

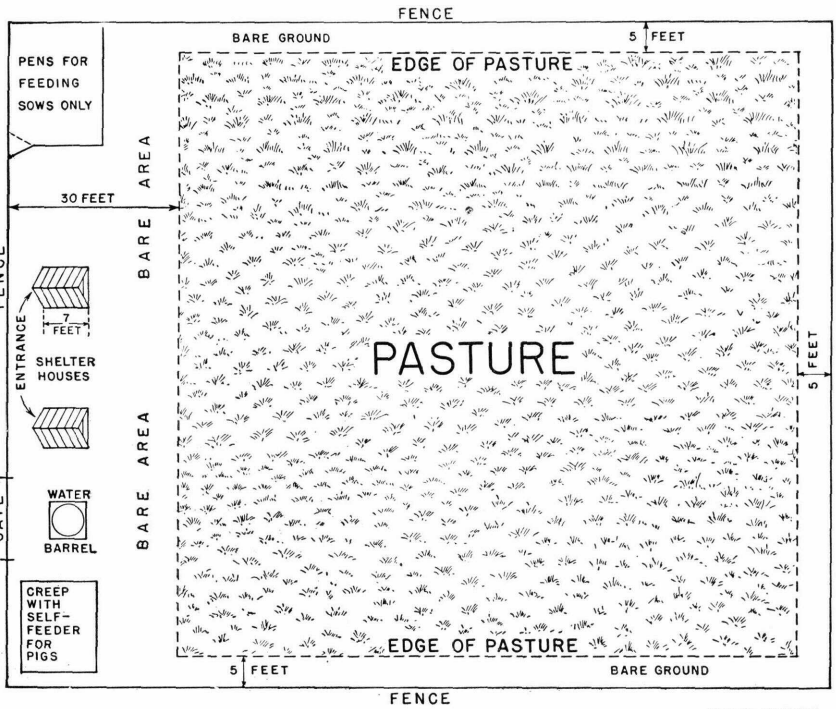

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FIGURE 28.—Kidney-worm control plan.

pasture receives no drainage from areas occupied by the older breeding stock.

In short, the precautions to be followed are intended to protect the pigs from acquiring a marked infestation while they are with the sow, and to avoid any kind of infestation after weaning.

LUNGWORMS

Three species of lungworms, *Metastrongylus elongatus*, *M. salmi*, and *Choerostrongylus pudendotectus*, infest swine—*M. elongatus* and

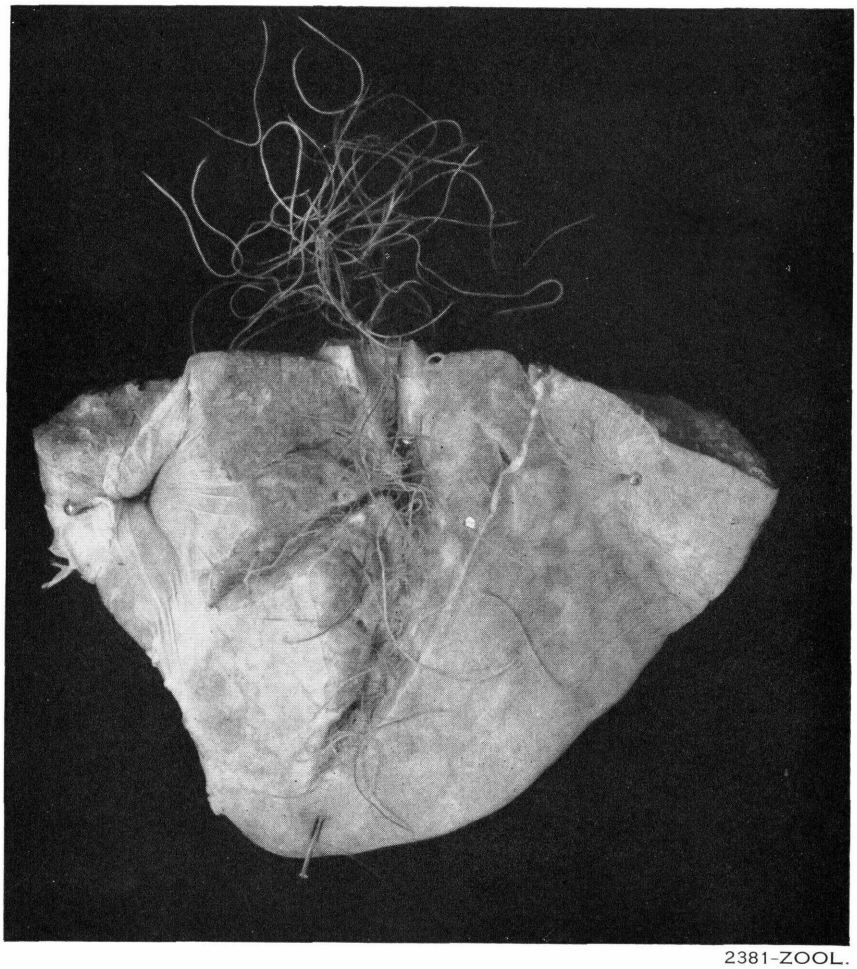

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FIGURE 29.—Nests of lung worms in lower portion of swine lung partially cut open to show them; lungworms removed to show their size and shape (top).

C. pudendotectus in relatively large numbers and *M. salmi* in relatively small numbers. All three species are long, slender, whitish worms, from one-half to 2 inches long by about one-fiftieth of an inch wide (fig. 29). These parasites are found occasionally in the windpipe, more often in its two main branches (the bronchi), their preferred

location, however, being the smaller bronchi and the bronchioles (the finer branches of the bronchi), and especially those in the lower portions of the lungs. So far as is known, the three species of lungworms which parasitize swine are equally injurious, the degree of injury depending on the number of worms present in individual pigs.

Lungworms may also serve as carriers of virus diseases affecting pigs. Evidence indicates that swine influenza may be transmitted to pigs when infected lungworm larvae reach the lungs.

Life history (fig. 30).—The female lungworms in the lungs of infested pigs produce large numbers of eggs, which are coughed up, swallowed, and eliminated with the droppings. At that time each egg contains a young worm. Earthworms, or angleworms, feeding on swine manure or on soil contaminated with swine manure, swallow the eggs, which hatch and develop in the body of earthworms to a

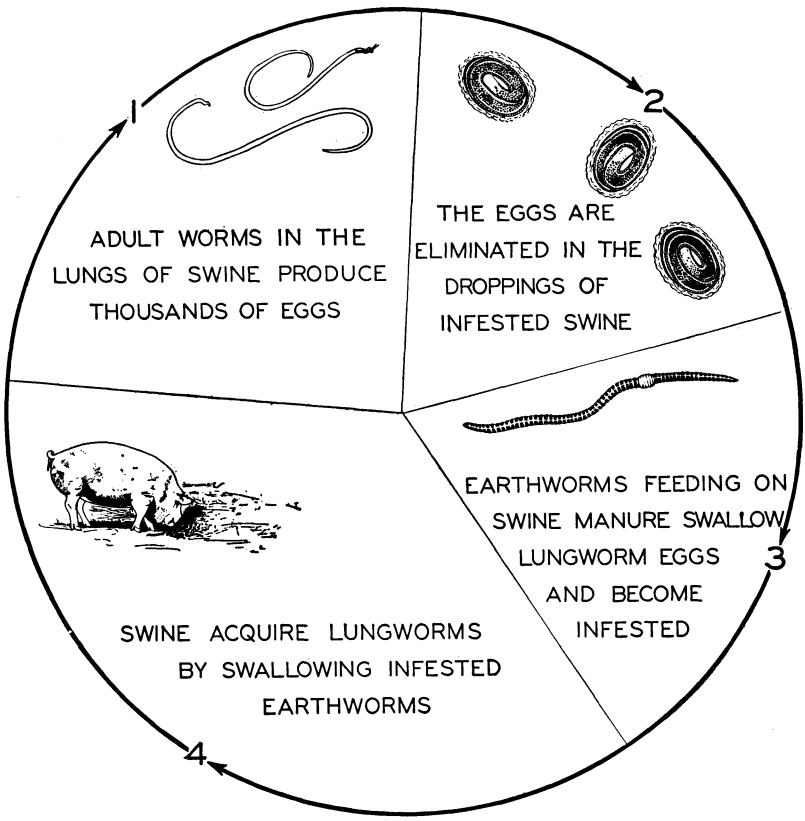

FIGURE 30.—Life cycle of swine lungworms.

stage that is infective to swine. Pigs acquire a lungworm infestation as a result of swallowing infested earthworms which they bring to the surface by rooting. A single earthworm may harbor from several to 2,000 or more lungworm larvae; the larger number is sufficient to produce a heavy infestation in a pig which might swallow such a heavily infested worm. The lungworm larvae in infested earth-

worms become free in the pig's alimentary canal as a result of the process of digestion. Once they are free in the intestine, the young lungworms penetrate its wall, and follow the course of the lymph, which leads to the heart and thence to the lungs. (Lymph is a body fluid similar to blood, but lacking the elements which give blood its red color.) In about 4 weeks after a pig has swallowed infested earthworms, the lungworms have developed to the egg-producing stage, and the droppings of such a pig can infect a fresh crop of earthworms.

Damage.—Symptoms of severe lungworm infestation in young pigs include coughing, difficulty of breathing, loss of appetite, weakness, and failure to grow. These conditions may cause death. In older hogs, coughing and shortness of breath are outstanding symptoms. In heavy infestations the finer bronchi and bronchioles are plugged with worms, and this produces a localized pneumonia. During the early stages of invasion by the worms, the lungs are peppered with hemorrhages resulting from the perforation of the walls of the delicate blood vessels in the lungs. In infestations of long standing, the posterior tips of the lungs commonly show grayish, hardened areas, marking the position of worms in the bronchi and bronchioles.

Treatment.—No established medicinal treatment is effective in removing these worms from the lungs; but a new drug, cyanacethydrazide, has shown promise in experimental infections. Infested animals should be taken off the pasture or out of the lot and placed in a dry, clean pen, preferably one with a concrete floor, to insure against further infestation from swallowing infested earthworms. While kept in isolation, sick pigs should be supplied with milk and other nutritious, appetizing food, safe drinking water, and good bedding that is renewed at fairly frequent intervals.

Prevention.—The control of lungworm infestation in pigs involves arrangements that will reduce the number of earthworms on pastures and lots and prevent rooting. Earthworms thrive in old hog lots in which manure and litter accumulate, in old strawstacks, on permanent pastures, and in low fields which receive drainage from higher fields. Well-drained fields, on which crops are cultivated seasonally, contain comparatively few earthworms.

Effective control of lungworm infestation involves the use of the sanitation system of swine management, the absolute avoidance of old hog lots, and the selection of well-drained pastures, fencing off, if necessary, the lowest portions to which rain and wind carry manure and other litter. As an additional precaution, it is important to ring the noses of swine to prevent excessive rooting.

TRICHINA

Trichinae, *Trichinella spiralis*, are slender threadworms, living in the small intestines of swine as adults, in the blood as migrating larvae, and in the muscles as encysted or encapsulated worms. The adult worms in the small intestines are from one-sixteenth to one-sixth inch long and about as wide as a very fine thread; the migrating worms in the blood are microscopic in size; the encapsulated larvae in the muscles are spirally rolled, and about one twenty-fifth of an inch long, but are not ordinarily visible to the naked eye. Trichinae infest human beings, rats, mice, dogs, cats, and other meat-eating animals, as well as swine.

Life history (fig. 31).—Adult trichinae in the intestines are rather short-lived, but, before they die and pass out with the droppings, the females produce numerous young worms, which are deposited directly in the lymph spaces in the intestinal walls. From the lymph channels the worms reach the large blood vessels leading to the heart, the heart itself, and the blood vessels leaving the heart, and are carried by the blood to all parts of the body. When the young worms in the blood stream reach the muscles they penetrate the muscle fibers and grow at the expense of the muscle tissue. About 3 weeks after they get into the muscles the young worms have attained their maximum size and become spirally coiled, while a thin membrane or cyst about

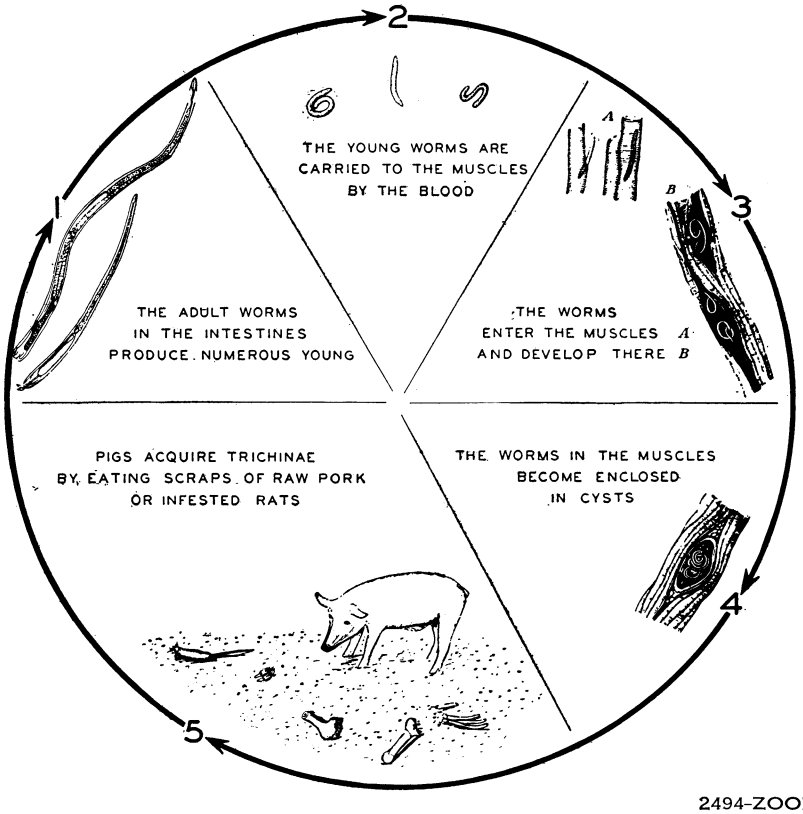

FIGURE 31.—Life cycle of trichinae. (Worms shown highly magnified.)

one-fiftieth of an inch in diameter forms around each worm. Occasionally two or more worms are enclosed in a single cyst or capsule. The encapsulated worm is trapped in the muscles and can develop no further until the muscle tissue in which it is lodged is eaten by another susceptible animal. Pigs acquire trichinae as a result of eating scraps of pork containing the encysted worms, or as a result of eating dead pigs, dogs, cats, rats, or mice harboring encysted trichinae. Rats and mice become infested as a result of eating scraps of infested pork or infested rats and mice. Dogs and cats become infested as a result of eating infested raw pork or infested rats or mice. Human beings

become infested usually as a result of eating raw or imperfectly cooked pork infested with trichinae.

When a hog or any other susceptible animal swallows flesh containing encysted trichinae, the flesh and the cysts are digested in the stomach, thus liberating the young parasites, which then pass into the intestines; in a week or so they begin producing the new generation of young worms, which migrate to the muscles and ultimately become encysted there.

Damage.—The disease produced by trichinae, known as trichinosis, is practically never diagnosed in swine during life because other and better-known diseases of these animals show similar symptoms. Consequently, trichinosis in swine is probably confused with other diseases. Within a few days after a large quantity of trichinous meat has been eaten, affected hogs take no food, vomit, crouch in the straw, and move about with difficulty. When the young worms invade the muscles, beginning about the second week after infestation, affected hogs move about stiffly and often lie motionless in one place. They may show marked swelling, especially in the eyelids. Recovery is the rule unless the infestation is very severe. With the encystment of the worms in the muscles the symptoms gradually disappear and the animals regain their appetite and apparently make a good recovery. Although the muscles, which undergo important changes when invaded by the parasite, become normal in appearance on recovery of the animal, the encysted worms may remain in them for a year or longer. The symptoms, which are observed in rather severe experimental infections, may be partially or entirely lacking in light infestations.

Treatment.—No effective treatment for trichinosis in swine, or in any other animal, is known.

Control.—Control of trichinosis in swine involves management designed to eliminate the sources of infestation. As swine acquire trichinae by swallowing trichinous pork or the flesh of infested rats, mice, or other animals, it is important to eliminate these sources of infestation. Hogs may become trichinous if they receive garbage containing uncooked pork or offal from slaughterhouses. The incidence of trichinosis in garbage-fed hogs is about five times that in grain-fed hogs. Therefore, do not feed uncooked garbage to hogs. Never leave dead hogs on the pasture or lot, where other hogs can eat them; bury the carcasses deep in quicklime, or, preferably, burn them. The swine-sanitation system (p. 21) will aid materially in controlling trichinosis and so reduce the chances of spreading a disease that is dangerous to human beings as well as to swine.

SUMMARY OF CONTROL MEASURES

The principal known methods of controlling internal swine parasites are briefly as follows:

Bladder-worm infestation may be prevented by the use of modern sanitary sewage disposal or sanitary privies on farms and in rural communities and by restricting the wanderings of dogs to keep them off hog pastures. Periodic treatment of dogs for the removal of tapeworms is an additional precaution.

Sanitation, involving the use of temporary pastures sown to suitable forage crops, selecting pastures that are well drained, and keeping them free from trash and litter are fundamental methods of controlling Protozoa, stomach worms, intestinal roundworms, threadworms, whipworms, thorn-headed worms, nodular worms, kidney worms, lungworms, and trichinae.

The use of pastures with bare areas is an additional precaution and affords an effective and practical method of controlling kidney worms, particularly in the South.

If temporary pastures cannot be made available, permanent pastures from which hogs have been excluded for at least a year may be substituted. Suckling pigs should be protected from association with older hogs other than their mothers. After weaning, and until they are ready for market, the pigs should still be protected from association with other hogs, especially the older breeding stock.

The pastures should have good fences to keep the pigs from getting into low, wet areas. Such areas harbor earthworms, grubs, and adult insects which convey, respectively, lungworms, thorn-headed worms, and stomach worms to swine. Wet areas in certain regions may harbor snails, that convey liver flukes and crayfish that convey lung flukes to swine.

Clean, well-fenced temporary pastures sown to suitable forage crops reduce parasitic infestation to a low level. Adequate supplemental feeding helps to minimize the effects of parasitism, and, by reducing the tendency of pigs to search for food by rooting, protects them from lungworms, which spend part of their life cycle in earthworms, and from thorn-headed worms, which spend part of their life cycle in white grubs. Ringing pigs' noses is a well-known method of preventing rooting.

Specific medication is not to be overlooked as a measure for the control of parasites. The judicious use of sodium fluoride, phenothiazine, and other effective remedies is important in the control of gastrointestinal parasites of swine.

Skim milk or whey can be used to protect pigs against the acquisition of nodular worms, whipworms, and, to a lesser extent, large roundworms. The skim milk or whey should be fed daily in lieu of one grain feeding, or for 3 days in succession in lieu of all other feed, at intervals of 2 weeks. When skim milk or whey is fed to prevent acquisition of worms as much should be given as the pigs will drink. When either regime is followed the parasites are either not acquired, or are acquired in such small numbers as to produce practically no injury to the host animal. Pigs so fed make satisfactory weight gains and remain in good condition.

Using no uncooked pork in hog feed, disposing properly of offal from hogs slaughtered on the farm and in country slaughterhouses, keeping rats and mice out of hog lots, and burning dead hogs or burying them deep will reduce trichinosis in hogs. A rigid adherence to the swine-sanitation system will control trichinosis effectively.

As a number of the parasites discussed in this bulletin are transmissible to human beings, a strict adherence to the sanitation system of management is important for safeguarding human health.

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